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Conference REPORTS

CONFERENCE ON SURVIVAL AND EMERGENCY RATIONS

QUARTERMASTER FOOD and CONTAINER INSTITUTE for the ARMED FORCES

CONFERENCE

ON

SURVIVAL AND EMERGENCY RATIONS

Held at the Knickerbocker Hotel, Chicago
5 September 1947

RESEARCH AND DEVELOPMENT BRANCH
Office of the Quartermaster General
QUARTERMASTER FOOD & CONTAINER INSTITUTE FOR THE ARMED FORCES
Chicago 9, Illinois

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GREETINGS TO THE CONFERENCE

The problem of survival where only minimum food and water are available poses problems to science and technology, the answers to which are fundamentally similar whether the emergency be on icebergs, life rafts, or the ground; whether it be occasioned by national emergency or disaster.

In recent months, definite progress has been made in the formulation of a satisfactory Survival Ration. This, in itself, is an accomplishment both tangible and significant. It is, however, additionally gratifying to know that the investigations involved have uncovered important findings in medicine, physiology, and food technology. I am, therefore, doubly pleased to greet this conference. I extend best wishes for further progress, and I urge everyone concerned to continue to devote his best effort in these, the final stages of this undertaking. The development of a satisfactory Survival Ration is indeed an important project, for the preservation of life is not only instinctive to man, it is also of fundamental importance for successful military operations.

THOMAS B. LARKIN
Major General
Quartermaster General of the Army

CONFERENCE ON SURVIVAL AND EMERGENCY RATIONS

(MORNING SESSION)

Research Aspects of Survival and Emergency Rations

CHAIRMAN - Dr. George H. Berryman

1. Welcoming Address.	Colonel Charles S. Lawrence, QM Food & Container Institute for the Armed Forces, Chicago, Illinois.
2. Brief Discussion of Accomplishments of Food Research Program.	Mr. George Gelman, QM Food & Container Institute for the Armed Forces, Chicago, Illinois.
3. Background of Survival Ration.	Dr. George H. Berryman, QM Food & Container Institute for the Armed Forces, Chicago, Illinois.
4. Significant Contributions to the Survival and Emergency Problem.	Dr. C. G. King, Scientific Director, The Nutrition Foundation, New York City, New York.
5. Utilization of Food Proteins	Dr. Pearl Swanson, Iowa State College, Ames, Iowa.
6. Food Acceptance Test on Food Bars.	Dr. W. Franklin Dove, QM Food & Container Institute for the Armed Forces, Chicago, Illinois.

Intermission

7. Recent Findings on Project "The Utilization of Proteins and Amino Acids".	Dr. J. B. Allison, Rutgers University, New Brunswick, N. J.
8. Recent Findings on Project "Protein Metabolism Studies on Reduced Caloric and Water Intake".	Dr. David Schwimmer, New York Medical College, Welfare Island, New York.

Luncheon

(AFTERNOON SESSION)

Developmental Aspects of Survival and Emergency Rations

CHAIRMAN - Dr. Howard D. Lightbody

9. Discussion of Survival Ration and Emergency Food Items Recently Developed.	Dr. Harry L. Fevold, QM Food & Container Institute for the Armed Forces, Chicago, Illinois.
10. Report of Food Acceptance Test on Food Food Bars.	Mr. J. E. P. Libby, QM Food & Container Institute for the Armed Forces, Chicago, Illinois.

11. Results of Recent Studies on the Air-Borne Life Raft Ration. — Capt. James L. D. Roth, M. C. Aero-Medical Laboratory, Wright Field, Dayton, Ohio.

12. General and Clinical Aspects of the Assessment of Nutritional and Metabolic Condition in the Field. — Dr. Robert E. Johnson, Director, Medical Nutrition Laboratory, Chicago, Illinois.

Intermission

13. Round Table Critique and Suggestions for Future Work. — Lt. Col. Manley C. Perry, Chief, Rations Planning Office, QM Food & Container Institute for the Armed Forces, Chicago, Illinois.

The following participated in the discussion:

Dr. C. G. King, Sci. Dir. Nutrition Foundation.
Colonel James C. Barta, Strategic Air Command.
Colonel George F. Keenan, A.A.F. Liaison Office, OQMG.
Colonel Henry Dittman, Headquarters, Army Air Force.
Lieutenant Colonel John E. Crowley, Office of the Air Quartermaster.
Dr. True Robinson, Aeromedical Laboratory.
Lieutenant Colonel Ralph H. Wiltamuth, Headquarters, Army Ground Forces.
Lieutenant Colonel Richard K. Boyd, Army Ground Forces, Board No. 3.
Lieutenant Colonel Richard L. Lewis, Research & Development Br., OQMG.
Lieutenant Commander Richard T. Power, USN Liaison Officer, QMF&CI.
Lieutenant John C. Herron, Bureau of Supply and Accounts, U. S. Navy.
Major Fenwich W. Holmes, U. S. Marine Corps.
Lieutenant Commander W. J. Conely, Coast Guard.
Mr. Emory W. Thurston, Emory W. Thurston Laboratories, Los Angeles.

14. Adjournment — Colonel Charles S. Lawrence

(EVENING SESSION)

Research Problems Related to Survival and Emergency Rations

CHAIRMAN - Dr. George H. Berryman

15. Round Table Discussion

The following were in attendance:

Dr. James B. Allison	Dr. Robert E. Johnson
Dr. H. S. Belding	Dr. C. G. King
Dr. Sadie Brenner	Dr. Howard D. Lightbody
Dr. Paul R. Cannon	Dr. Daniel Melnick
Dr. H. J. Deuel	Dr. Herbert Pollack
Dr. H. L. Fevold	Dr. True W. Robinson
Mr. George Gelman	Capt. James Roth, MC
Dr. Austin Henschel	Dr. David Schwimmer
Dr. A. Stuart Hunter	Dr. Pearl Swanson

12. Results of Recent Studies on the Nutritive Value of Survival Like Raft Ration. — Capt. [illegible], M.C., Aero Medical Laboratory, Wright Field, Dayton, Ohio.

13. General and Clinical Aspects of the Assessment of Nutritional and Metabolic Condition in the Field. — Dr. Robert E. Johnson, Director, Medical Nutrition Laboratory, Chicago, Illinois.

Discussion

14. Round Table Critique and Suggestions for Future Work. — Lt. Col. [illegible] C. Perry, Chief, Ration Planning Office, QM Food & Container Institute for the Armed Forces, Chicago, Illinois.

The following participated in the discussion:

Dr. C. G. King, Sci. Dir., Nutrition Foundation.
Colonel James C. Davis, Strategic Air Command.
Colonel [illegible], A.A.F. Liaison Office, OQMG.
Major [illegible], Headquarters, Army Air Forces.
Lieutenant Colonel John E. [illegible], Office of the Air Quartermaster.
Dr. [illegible], Aeronautical Laboratory.
Lieutenant Colonel Ralph E. Williams, Headquarters, Army Ground Forces.
Lieutenant Colonel Richard [illegible], Army Ground Forces, Board No. [illegible]
Lieutenant Colonel [illegible], Research & Development Br., OQMG.
Lieutenant Commander [illegible], Liaison Officer, OQMG.
Lieutenant [illegible], Bureau of Supplies and Accounts, U. S. Navy.
Major [illegible], U. S. Marine Corps.
Lieutenant Commander W. J. [illegible], Coast Guard.
Mr. Henry W. Thompson, Henry W. Thompson Laboratories, Los Angeles.

15. Adjournment — Colonel Charles S. Lawrence

AFTERNOON SESSION

Research Problems Related to Survival and Emergency Rations

Chairman - Dr. George R. Cowgill

16. Round Table Discussion.

The following were in attendance:

Dr. James B. Allison	Dr. Robert E. Johnson
Dr. R. J. Block	Dr. C. G. King
Dr. Josef Brozek	Dr. [illegible]
Dr. Paul R. Cannon	Dr. [illegible]
Dr. H. J. Deuel	Dr. [illegible]
Dr. [illegible]	Dr. [illegible]
Mr. [illegible]	Capt. [illegible], M.C.
Dr. [illegible]	Dr. [illegible]
Dr. [illegible]	Dr. Pearl Swanson

CONFERENCE ON SURVIVAL AND EMERGENCY RATIONS

(MORNING SESSION)

Research Aspects of Survival and Emergency Rations

DR. BERRYMAN:

We shall begin this morning's session with greetings to the conference from Col. Lawrence, Commanding Officer of the Quartermaster Food and Container Institute for the Armed Forces. Colonel Lawrence!

COL. LAWRENCE:

Ladies and gentlemen, having to face such an august group as this leaves me almost speechless. I suppose that I should have a carefully prepared and memorized address, but I learned rather early in life that it is sometimes a mistake to spend too much time in preparing and memorizing talks. In my young and more irresponsible days I was studying in one of the agricultural schools and had occasion to prepare a talk on the care and breeding of swine. I spent days and nights preparing my speech and memorizing it. At the same time I was going with a very beautiful girl, with gorgeous red hair and blue eyes. I was very much in love with the young lady. A few days before I was to deliver my talk on swine, I got her out in a rowboat and began to propose. I had been talking for about 15 minutes before I discovered I was talking about pigs insead of love. Right there I muffed my chance of marrying one of the richest and most productive oil fields in Oklahoma. I have never gone in for prepared addresses since.

I would like to say the Food and Container Institute of the Quartermaster Corps is happy to have such a group present for this conference. The problem of survival rations is one of the most urgent of the military feeding problems confronting the Armed Forces at the present time. Modern conflict extends beyond the military arm and involves in some instances large numbers of our civilian population. At one time survival rations were used for the Armed Forces only. Now we have to contemplate the use of survival rations for many thousands of the civilian population. For that reason the survival ration takes on increased importance. I am not an alarmist about the prospect of war in the immediate future, and we hope that we will never have armed conflict again, but I think it behooves us to pay attention to the old Chinese prophecy which reads, "Enjoy yourself; it is later than you think". I think that for our use we might say, "Prepare ourselves, it is later than we think".

May I say again that I want to welcome you on behalf of the Quartermaster Food and Container Institute. I am sure that great good will come from this conference on survival and emergency rations.

DR. BERRYMAN:

Thank you, Col. Lawrence. It gives me great pleasure to introduce the Technical Director of the Institute, Mr. George Gelman.

MR. GELMAN:

Mr. Chairman, officers, ladies and gentlemen, it is very gratifying indeed to have assembled in one room the Armed Forces, university scientists, and industry scientists to share with us in a discussion of the survival and emergency type ration. This ration, perhaps more than any other, can be truthfully said to be scientifically designed and solidly based on fundamental studies of physiology and nutrition.

The speakers who are to follow will give you the evidence and facts upon which the emergency ration in its present developmental stage is founded. I would like in a collateral way to indicate that the research program of the Institute in cooperation with a number of university research departments and Government research agencies has made it possible for us to have information that is helpful in estimating the shelf life or the stability of the ration that is to be developed, and which, when confirmed by actual storage and field studies, will in considerable degree measure the acceptability of that ration. Such a measure has never been entirely possible in the past. It is not by any means perfect now, but it is far enough along for us to

place reliance on the background information which has been developed in the universities and in our laboratory.

Our program of outside research is centered largely in 3 categories: (1) research in methods of preventing deterioration, whether they be chemical, microbiological, or physical; (2) research in the field of food acceptance, which embraces 3 general categories of studies -- food habit or psychosociological studies, psychophysiological studies, which attempt to ascertain the nature of the mechanisms controlling food intake, and psychophysical studies, which provide information we need to obtain a screening of acceptability in the laboratory, using human beings as research tools to provide information that we cannot measure chemically or physically by the usual laboratory methods; and in addition, of course, (3) the nutrition program which has made an impact on this particular problem of survival, and about which you will hear more from Dr. Swanson, Dr. Allison, Dr. Schwimmer, and Dr. Berryman, and in the afternoon from Capt. Roth, Dr. Fevold, and others. We are fortunate in having Dr. Mitchell's contribution -- a tremendous survey he is undertaking on nutrition and resistance to climatic stress. Last week when he was visiting the laboratory, Dr. Mitchell told me that 2,000 abstracts covering his report on that problem will soon be available.

There have been numerous contributions from many distinguished persons in this country to our general problem of Army ration nutrition, and it all has a bearing on this specific problem of survival rations. I hope some time today we will have a chart brought up to this room which will illustrate diagrammatically the nature and scope of this program. In about 2 months we hope to mail to you a detailed analysis of our entire research program described by projects and phases.

We have had a somewhat late start. I would like to make my contribution by stopping now so that you may have the full time of the other speakers. Our next speaker will be Dr. Berryman.

DR. BERRYMAN:

Background of Survival Ration[1]

In order to survive until rescue, the castaway must reduce to a minimum the adverse physiologic effects due to environment, so that he does not die from exposure; he must conquer fear; he must either find potable water, or at least keep his body water losses to a minimum; he must replace salt losses; and finally, for a period of long survival, he must have access to food. These five factors are listed in a sequence approximating relative importance; let us examine them in greater detail.

Environmental protection is of first importance. Occasionally, the environment may be irremediable, as for example, when a flier is ditched into very cold waters such as those around the Aleutians. Here, death from exposure is reputed to occur in less than an hour. In the majority of circumstances, however, certain steps can be taken to cope with environment. Thus, in the Arctic, provided the survivor is adequately clothed against freezing, it will be of further aid to try to avoid sweating and to favor ventilation by opening clothing at the neck and wrists and loosening the waist. The vascular circulation should be aided by wearing clothing loosely. Dry grass or kapok from airplane cushions makes excellent insulation for the feet. Clothing can be kept as dry as possible to deter freezing. Shelter can be improvised by building "bough dens" reinforced with snow, or snow caves, and by the judicious use of snow banks. In the summer, sunburn can be guarded against, and sun glasses may be improvised to prevent snow-blindness.

Appropriate steps can also be taken in the tropics. Staying in the shade and other measures sparing of body water are of paramount importance, for obviously here the problem of water and salt is critical. The need for avoiding mosquitoes is more or less a well known precaution, as well as the use of malaria-suppressant drugs. Shelter from both sun and rain is usually facilitated by the profusion of trees and other vegetation. Measures to avoid ticks, leeches, spiders, scorpions. and the like must also be taken. Protection against poisonous and irritating plants is also necessary.

[1] For bibliography on survival rations see Appendix A.

Control of one's fear, or conversely, bravado, is considered by many to be of almost equal importance with the necessity for controlling environmental disadvantages. Many a castaway on a raft has hastened the end by resorting to large quantities of sea water as a means of assuaging thirst. Many a castaway on land has hastened the end by an unjudicious decision to travel in the height of the sun. The continuing desire to live may be listed as one personal trait that stands out in importance above others. If, then, it be granted - as it is universally - that food may favorably influence the kind of decision which the castaway makes, and aids morale and courage, it follows that a survival ration may be a significant factor in saving life.

The need for water is not immediate, but it may arise early in the course of survival, depending on the environmental temperature and the amount of physical exercise. Table 1, taken from Army Air Forces Manual 64-0-1, illustrates this point. While certain measures can be taken to conserve water, the minimum daily quantity required for the average person in a temperate environment has been estimated by Gamble to be about 700 cc. This is, of course, considerably less than the amount normally consumed, which may average about 2.5 liters or more, depending on work and temperature. An interesting and important point about the body's requirement for water is that it may be profoundly influenced by the kind and amount of food that is available. Protein increases the requirement, while carbohydrate and fat decrease it.

The need for salt is closely related to that of water. The Food and Nutrition Board, National Research Council, lists five grams daily as being a liberal allowance, but further designates the average normal intake of salt to be as high as 10-15 grams per day, when water intake is not more than 4 liters. For every liter of intake above four, an additional gram of salt is recommended. It would seem, however, that once adjusted to the environment, the average person may not need as much as this, for the salt concentration of sweat is then considerably lower. Basically, the needs are to replenish the salt lost by the body.

TABLE 1

DESERT WATER DATA TABLE

Maximum Daytime Temperatures In Shade	Entire Water Supply Per Man	Approximate Survival Days (When Resting In Shade At All Times)	Approximate Survival Days (When Traveling Only At Night & Resting In Shade By Day. Also Distance You Can Travel)	
VERY HOT 100° F. & above	No water	2-5	1-3 days	20 miles
	1 quart	2-5 1/2	2-3 1/2 days	20 miles
	2 quarts	2-6	2-3 1/2 days	25 miles
	4 quarts	2 1/2-7	2 1/2-4 days	30 miles
MODERATELY HOT 80° - 100° F.	No water	5-9	3-7 days	20-40 miles
	1 quart	5 1/2-10	3 1/2-7 1/2	20-45 miles
	2 quarts	6-11	3 1/2-8 days	25-50 miles
	4 quarts	7-13	4-9 days	30-60 miles
COOL Under 80° F.	No water	9-10	7-8 days	40-60 miles
	1 quart	10-11	7 1/2-8 1/2	45-75 miles
	2 quarts	11-12	8-9 days	55-100 miles
	4 quarts	13-14 1/2	9 1/2-11	60-150 miles

Adapted from: Army Air Forces Manual 64-0-1, "Survival", June 1945.

It is a truism that the castaway rarely dies from starvation.* The specific physiologic need for food in a survival situation is not a critical one, although as mentioned above, the psychologic aspects of the problem probably make food quite important from the overall standpoint. Insofar as actual starvation and its attendant inanition are concerned, it is reported that the castaway on a raft can "survive without food, but with ample water, for twenty to thirty days or longer, provided he is not subjected to physical strain, ..." This may be contrasted with average survival time without water, which probably does not exceed ten to fourteen days even under the most favorable circumstances. At sea, the maximum recorded period of survival without water is eleven days and it can be considerably less than that in some individuals.

It does not seem that all the nutritive components of food are needed in the same degree for survival. For preventing physical deterioration, calories and protein rate highest. (There is, however, a definite limit on the amount of protein that should be eaten, for the metabolic end products increase obligatory urine volume). Except for sodium, (as salt), minerals are not a critical factor. For the relatively short periods ordinarily involved in survival, there is no evidence from the physiologic standpoint justifying any concern for vitamins, provided the castaway was not originally in a depleted state.** Vitamin supplements may, on the other hand, exert a favorable psychologic effect, if they can fit into the ration conveniently.

Having rapidly reviewed the hierarchy of factors involved in survival, let us examine more closely the components of water balance, as a preliminary to considering the types of food suitable for a survival ration. The components of water exchange when there is no food intake are indicated in Figure 1. There are two items of expenditure; (1) water which leaves the body as water vapor by way of the lungs and skin - the so-called insensible loss, and (2) water removed by the kidneys. This total outgo is only in small part covered by water produced by oxidation of protein, fat, and carbohydrate. In fasting, there is an additional source of water from the cellular breakdown of body substance, but this does not contribute to general dehydration. As Gamble states: "This is water which, under the circumstances imposed by fasting, is physiologically expendible." In fasting, this source of fluid, together with water of oxidation, aids in maintenance of homeostasis. It will be noted from the diagram that water drunk under guidance of the sensation of thirst usually provides a generous margin over obligatory expenditure, indicated by the broken line, and so leaves a large surplus to be removed in the urine. One exception to this occurs in extremely hot environment, however, where thirst may not be a dependable guide to water requirements.

The larger component of the obligatory outgo of fluid is the insensible expenditure, and since this has a direct relationship to the metabolism of energy, it is apparent that at rest, it will be at a minimum. In the tropics, this is the basis for recommendations to avoid physical activity as much as possible, and to decrease the vaporization of body water as much as is compatible with maintaining body temperature. Usually the castaway in the tropics intuitively takes measures to decrease environmental warmth, and to substitute for the vaporization of body water other processes of heat removal. These measures are the following:

(1) Stay in the shade.
(Direct reduction of environmental temperature)

(2) Increase the cooling effect of breeze by removal of clothing.
(Promotion of convection)

(3) When at sea, periodically immerse in the sea water.
(Promotion of conduction)

(4) Wet clothing with sea water.
(Vaporization of sea water in place of body water)

* Thus, in the Arctic, clothing, shelter and signalling devices, fuel and heat, water may be listed as taking precedence over food; in the tropics, environmental protection, salt and water play a more important direct role than food.

** This statement might possibly require modification if survival periods exceeded, say, three weeks.

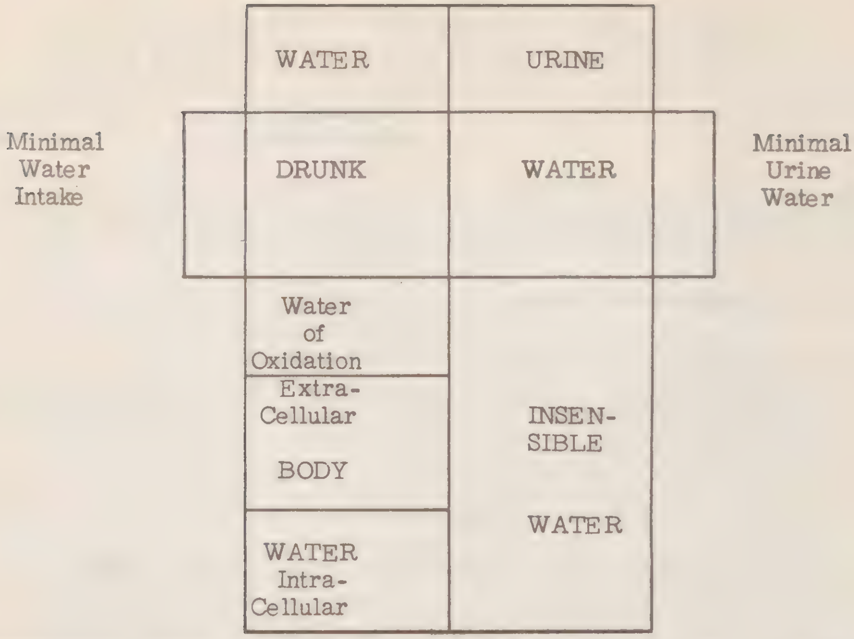

***FIG. 1. WATER EXCHANGE DURING FASTING, WITH SURPLUS WATER INTAKE**

*Taken from: "The Water Requirement of Castaways" by James L. Gamble, Proc. Am. Philos. Society, Vol. 99, #3, 1944.

An appreciation of the minimum water requirement can be gained by considering the concentrating power of the kidney. The total amount of metabolic solutes requiring excretion, divided by the maximum concentration that is ordinarily found to be within the capacity of the kidney (1.4 osmolar), provides a measure of the obligatory urine water. A specific example cited by Gamble illustrates the principle. A 24-hour collection of urine amounted to 1240 cc. having a freezing point depression of -1.19° C. An osmole of any solute lowers the freezing point of water by -1.86° C. Thus, $\frac{1.19}{1.86} \times 1240 = 794$ milliosmols of total solutes requiring excretion; and $\frac{794}{1.4} = 566$ cc. minimal urine volume, provided there is no impairment in kidney concentrating power.

Now, it is important to note that the urinary volume can be even further decreased if the castaway eats a type of food sparing body protein. This is usually considered to be carbohydrate, although fat may exert a similar effect, which may, however, be complicated by the production of a concurrent ketosis. A specific example of the effect of carbohydrate can be cited, again taken from Gamble. Table 2 presents the essential data. It is seen that, when compared with the results found in fasting, feeding of 100 gm. of glucose has two effects upon water balance: (1) favorable - in that renal water is decreased, and (2) unfavorable - in that there is a decrease in the amount of body water arising from extracellular and intracellular sources. Since, however, the latter is less than the former, the net result is a gain of 140 cc. of water to the individual, as well as a sparing of his bodily tissue. Thus, 100 cc. of water requirement for fasting can be replaced by glucose, and the incident benefits of glucose (tendency to avoid inanition and lassitude, and to maintain cheerfulness) are obtained. In addition, carbohydrate, when taken in sufficient quantity, prevents the characteristic Ketosis of starvation.

Table 3 indicates the role that organic acids of ketosis may play. It is seen that the absence of these substances when glucose is given accounts for thirty-eight percent of the total reduction in solute output. Thus, both the anti-ketogenic effect of glucose and its protein sparing effect reduce the solute output, and thereby conserve body water.

There is yet another factor, although a slight one, involved in water balance. This pertains to water of oxidation. Table 4 indicates the relative amounts of water produced by

TABLE 2

EFFECT OF GLUCOSE ON WATER EXCHANGE

Subject M. G.	Minimal Urine Water cc.	Available Body Water, cc.
Fasting	521	518
100 gm. glucose	223	360
Reduction.	298	158

Gain in water exchange 298-158= 140 cc.

Values average per 24 hrs. for 6-day periods omitting first day.

Taken from: "The Water Requirement of Castaways" by James L. Gamble, Proc. Am. Philos. Society, Vol. 88, #3, 1944.

TABLE 3

EFFECT OF GLUCOSE ON OUTPUT OF SOLUTES IN URINE

Subject--M.G.	Milliosmols per 24 Hrs.			
	Total Solutes	Organic Acids	NH_4	Org. Ac. + NH_4
Fasting	784	133	86	219
100 gm. glucose.	362	39	21	60
Reduction	422	94 +	65	= 159
	159/422	0.38		

Data from 6-day periods (omitting first day).

Taken from: "The Water Requirement of Castaways" by James L. Gamble, Proc. Am. Philos. Society, Vol. 88, #3, 1944.

TABLE 4

WATER OF OXIDATION FROM FOOD

Substrate of oxidation 1 gm.	H_2O produced (gm.)
Glucose	0.600
Sucrose	0.579
Starch or glycogen	0.556
Fat	1.071
Protein	0.396

the oxidation of 1 gram of carbohydrate, fat or protein. It will be noted that the water of oxidation of fat is high by comparison, but more importantly, that of protein is least - another reason why the level of protein consumed in the absence of water must be limited.

In summary, the following points are salient for the conservation of the body water of the castaway:

(1) in isolation, where water supply is a problem, the type of food consumed may play an important role in prevention of rapid dehydration;

(2) the chief component of food adversely affecting water balance is protein, because its metabolic end products require water for excretion, and less important, its water of oxidation is less than that of carbohydrate or fat;

(3) carbohydrate and fat exert a protein-sparing effect, and thus decrease the amount of obligatory urine; carbohydrate also aids in preventing ketosis, and is much less nauseating than are equal quantities of fat;

(4) insensible loss of body water should be kept at a minimum by limiting activity and promoting cooling.

Turning now to the application of these principles to the development of rations, it will be recalled that one of the early survival rations - the Life Raft Ration - was composed of 100 grams of pure carbohydrate in the form of Charms candy. On the basis of the foregoing, it is apparent that this ration was based on sound physiologic principles. The other Survival or Emergency Ration, the D Bar, contained other nutrients that were surprisingly close in quantity to the amounts presently proposed, as we shall see. However, there were also several objections to these rations on acceptability grounds. Thus the candy ration was reported to cause sore mouths and to be unappetizing for any length of time exceeding a day or two. Candy is thirst provoking to many. The D Bar depressed appetite, caused gastro-intestinal upsets in some and, in general, was claimed to be thirst provoking because of the chocolate content. These rations were, therefore, not ideal; yet, in retrospect, they had several happy properties in relation to size, shape, stability, and caloric density. In addition, they could play an important role in contributing to the morale of the subject. At this point, we might digress momentarily to state that to many, the psychologic problems of survival far outweigh the physiologic. This feeling about the relative unimportance of what (and if) one eats in survival circumstances is seen in such statements as "the best survival ration is a rapid rescue", and others of that nature. This line of thought might be pursued further, however. If food is to be provided for psychologic reasons primarily, there is still no reason why it should not also be physiologically sound and of such a nature as to conserve physical and mental efficiency. After rescue, overall recovery with return to duty, wound healing, etc., will proceed at a far faster rate when extreme depletion has been prevented. By all criteria, therefore, if a survival ration is to be made, it should not be planned oblivious of food values.

In 1943 there occurred the most important technologic achievement of the war, as far as survival is concerned. This was the rendering of sea water potable by a desalination technique. A solar still was also developed. The upshot of these advances was that in many situations at sea, dehydration was no longer the factor completely limiting the kind of food that could be used in survival. It was estimated that an average 800 cc. of water could be depended upon daily as the combined output from desalination kit, solar still, and from rainfall. This turn of events roused again the conviction that many had held previously; namely, that while survival rations must necessarily be high in calories and sparing of body water, they should nevertheless contain familiar and well-liked food items, should be less confection-like, and furthermore, should contain as much protein as possible in the interests of preventing marked loss of body protein. The big question was -- how much protein could be incorporated for a water intake presumably averaging 800 cc. per day, and what source of protein would favor the attainment of nitrogen balance? This last factor involved the amino acid make-up of protein -- and this was a field only recently explored, insofar as the familiar human foods were concerned. As a means of obtaining the needed information, several research projects were established through the Committee on Food Research, Quartermaster Food & Container Institute for the Armed Forces. Within the past two years, valuable information has been obtained, not only relating to these immediate problems, but also in the basic physiology of low-calorie, low-protein feeding. These will be discussed briefly.

Early in the program of investigation, there emerged one finding that appears to be basic in feeding the small amounts of food characteristic of survival rations. Swanson, working at Iowa State College, found that egg protein apparently conserved body protein in protein-depleted animals, and caused an unexpectedly marked reduction in the amount of urinary nitrogen excreted on a protein-free diet. This work was then repeated and verified

by Swanson, as well as by Allison and co-workers at Rutgers University, using rats and dogs respectively as test animals. Furthermore, this effect was similar to that obtained when an equivalent amount of dietary nitrogen was supplied in the form of the ten essential amino acids. The effect seemed to be related to the high methionine content of egg protein, for the addition of dl-methionine to diets containing proteins other than egg resulted in greater nitrogen sparing.

Here was an exciting possibility for use in survival ration planning. However, verification in human subjects was needed. This was undertaken initially by Schwimmer and co-workers at New York University. It was later investigated by R. M. Johnson and co-workers* at the University of Southern California, and also coincidently by Cox and co-workers at Washington University School of Medicine, St. Louis, and at New York University. The overall results were strikingly similar, and served to point up the great care needed in applying to humans results obtained by animal experimentation, even though the latter is a necessary and important forerunner. For in the human, no nitrogen-sparing effect due to added methionine was found such as that observed in rats and dogs. The conclusion was reached that a difference in species requirement for methionine was responsible for the difference in results.

At about the same time, additional work was begun on other phases of the low-protein, low-calorie intake problem by Schwimmer and associates. Comprehensive investigations upon several series of human volunteers undergoing twenty-eight dietary regimens were carried out. These investigations were based on the previous findings discussed above, and were designed to investigate several important questions that had arisen as a consequence. The resulting data, together with those originally obtained, form the basis for the present planning of the Survival ration. The immediate applicable findings** of the New York group were these:

1. Nitrogen sparing is absent in the 400-500 calorie range of feeding (level of standard Life Raft Ration).

2. Nitrogen utilization is optimal at 1500-1800 calories when 20 grams of protein (derived from dehydrated fermented egg white) are fed. When 40 grams are fed, a striking improvement in nitrogen balance occurs at all levels from 900 to 1800 calories, and the net amount of nitrogen retained by the body is greatest at the 40 gram protein intake level.

3. Urinary volumes are not increased when as much as 20 and 40 grams of protein are fed at 1500-1800 calories, averaging 30-60 cc. less than when no protein is ingested at 450 calories, and 115-145 cc. less than when 10 grams of protein are given at 450 calories.

In addition, the superiority of egg white over certain other types of protein was again reported. This was significant, for it provided verification of the earlier findings in animals that were withheld from application to survival ration planning when the species difference in the methionine effect was uncovered. The findings of Schwimmer and co-workers showed very clearly that for short periods of time, when egg white was the sole source of protein, there was a marked reduction in nitrogen excretion*** as compared with the results obtained when lactalbumen (high ash content) or malted milk protein was used, or no protein at all. This same effect was obtained at both the 20 and 40 gram levels of protein intake. The basis for the apparently superior effect of egg protein over many other proteins is apparent from a tabulation of the amino acid content of egg white and whole egg versus certain other foods. See Table 5.

[It will be noted that the egg white and whole egg values per 100 grams exceed man's average requirements -- Columns 1, 2, and 3 -- while none of the other common proteins approach the egg in biologic value, considering all the component amino acids, with the prominent exception of SERUM PROTEIN.

* Under the direction of Dr. H. J. Deuel.

** These findings were obtained over experimental periods of 5 days only, however.

*** It is recognized that to some, nitrogen-balance considerations may not be acceptable as a criterion for Survival feeding policy; i.e., blood protein and hemoglobin regeneration may be equally valid criteria.

TABLE 5.

APPROXIMATE PERCENTAGE OF AMINO ACIDS IN VARIOUS FOODS
(BLOCK & BOLLING)

AMINO ACIDS	1 MAN'S AVERAGE REQS.*	2 EGG WHITE	3 WHOLE EGG	4 EGG YOLK	5 EGG ALBUMEN	6 SERUM PROTEIN	7 CASEIN	8 LACTAL-BUMIN	9 WHOLE MILK COW	10 ZEIN	11 RICIN	12 PEANUT FLOUR	13 SOYBEAN MEAL	14 WHEAT FLOUR
	gm.													
ARGININE	3.5	5.8		8.2	5.7±0.3	5.8±0.3	4.1±0.2	3.5±0.5	4.3	1.6±0.2	11.7	9.9	5.8	3.9
HISTIDINE	2.0	2.2		2.6	1.8±0.3	2.6±0.1	2.5±0.3	2.0±0.3	2.5	0.9±0.2	0.0	2.1	2.3	2.2
LYSINE	5.2	6.5		5.5	4.5±0.5	8.0±0.4	6.9±0.7	8.0±1.1	7.5	0.0	6	3.0	5.4	1.9
TYROSINE	3.9	4.5		5.3	4.2±0.1	5.4±0.3	6.4±0.4	5.3±0.1	5.3	5.0±1.2	2.7	4.4	4.1	3.8
TRYPTOPHANE	1.1	1.6±0.2		1.6±0.	1.4±0.2	1.7±0.1	1.8±0.2	2.3±0.3	1.6	0.1	0.4	1.0	1.6	0.8
PHENYLALANINE	4.4	5.5		5.7	6	5.4	5.2±0.5	5.6	5.7	6.4±0.7		5.4	5.7	5.5
CYSTINE	3.8**	2.3±0.4		1.9	1.7±0.2	3.6±0.1	0.36±0.04	3.0±0.2	1.2	0.8±0.1	1.0	1.6	0.6±1.4	1.9
METHIONINE		4.4		2-3	5.[illegible]±0.3	2.1	3.5±0.3	2.8±0.2	2.8	2.4		0.9	1.5	3
SERINE					7.6		6-7	4.9						
THREONINE	3.5		4.9		3-4	6.3	3.9±0.1	5.3	1.8	2.4	2.7	1.5	4.0	2.7
LEUCINE	9.1		19.0±2.1		9.4	18	12.1	15[a]		23.7±[illegible].1	15[aa]	5.5	6.6	12.0±2.6
ISOLEUCINE	3.3		5.3±0.3			3	6.5			4.3±0.4		3.4	4.7	3.7±0.[illegible]
VALINE	3.8		4.4±0.6		6.8	6	7.0	4		2.4±0.9	2	4.0	4.2	3.4±0.5
GLUTAMIC ACID					16.3±0.2		22.8			35.6	19			
ASPARTIC ACID					8.2±0.2		6.3			3.4	2			
GLYCINE			2.5		1.9		0.5			0.0		5.6		7.2
ALANINE					7.4		5.6	0-1		9.9				
PROLINE					4-5		8.2			9-12	4			
HYDROXYPROLINE						0	2			1	0			

* Calculated
** Cystine plus Methionine
a Leucine and isoleucine
aa Includes isoleucine

Using egg white and whole egg values as criteria, zein, ricin, peanut flour, soybean meal, and wheat flour would have marked amino acid deficiencies, quantitatively speaking, when used as the only source of protein. (NOTE: It is quite possible that if some of these proteins were used together in a ration, they would supplement each other to the extent of obviating the quantitative deficiencies they have individually.)]

Other important data were obtained from this series of investigations. It was found that the frequency of feeding (one feeding versus four versus twelve) had no statistically significant effect upon the sparing of nitrogen or upon urine volume. The principle of frequent feeding requires further investigation, however, because it is reported that in the Arctic an overall feeling of well-being occurs from eating more often, and also because of the general belief that more efficient utilization of food in the body is promoted by feeding a given amount of food in small quantities as compared with a single large quantity.

Increase of caloric output did not appear to affect nitrogen balance or urine volume to any great extent. This finding, too, should be checked, for it is an important point. It may have a bearing on the situation in the Arctic where a greater amount of energy is needed, presumably due to factors not encountered in warmer regions such as (1) need for maintaining body temperature; (2) direct effect of cold upon B.M.R. when shivering or its preceding muscular tenseness occurs; (3) "hobbling" effect of Arctic clothing, which increases the caloric cost of any activity. It will be recalled that dietary protein at low levels of intake may or may not be used for tissue repair and replacement purposes depending on the fraction of the daily energy requirement that is supplied. Thus, in the Arctic, if a survival ration provides a smaller fraction of the daily energy requirement than was originally planned, the whole purpose of nitrogen sparing might be defeated.

Another interesting and important point which has been raised by this same series of investigations concerns the effect of fat upon the sparing of nitrogen. There is now some indication that the same nitrogen-sparing effect found to occur in the 1500-1800 calorie range, can also occur at a lower calorie level, provided the fat content of the diet is increased at the expense of the carbohydrate. This finding is at once both important and potentially dangerous. It is important in that the foot soldier under survival circumstances requires as compact and calorically high a ration as can be devised for him to carry conveniently, and in that it will permit the easier carrying of emergency food for longer periods of time, while presumably inhibiting hunger. It is somewhat dangerous, however, in that the goal of high caloric density may be permitted to supersede that of highest palatability.* Any diet containing too much fat would not only be nauseating to most, but might also dispose towards a condition of ketosis and acidosis. Above all other considerations, however, there is every indication that such a ration would lack palatability - and paradoxical though it may seem, there is a considerable amount of evidence that the castaway will not "eat anything", even though starving.

It is pertinent, now, to appraise where we stand in the actual development of a survival ration. On the basis of the previously described evidence that was obtained through a practical and intensive program of research coordinated and brought to overall fruition through the efforts of Dr. Samuel Lepkovsky, the indications now are that the nutritional characteristics of the Survival Ration should be as follows:

a. Total caloric intake - 1800 calories per man per day.

b. Proportions of carbohydrate, fat and protein -

Protein -- 34-50 gms. per day (8-10% of calories)
Fat -- 40-60 gms. per day (20-30% of calories)
Carbohydrates -- 275-325 gms. per day (60-70% of calories)
Vitamins and minerals -- as provided in the natural food composition of the ration.

c. Food composition - Protein sources of highest nutritional value; e.g., dehydrated whole egg or egg white, rice flour, dehydrated skimmed milk; fat sources must be those likely to undergo a minimum of deterioration; carbohydrates chiefly dextrin, soluble starches, and sucrose.

* Then, too, it is desirable to supply as much of the daily caloric requirements as possible; therefore, many feel that additional fat should be considered from that standpoint, rather than only as a means of decreasing the size of the ration.

d. Highest order of acceptability - Palatable, edible under temperature extremes (-50° to $+120^{\circ}$ F.), non-thirst-provoking (subjectively), swallowed easily with restricted free water supply (approximately 800 cc. per day), and should provide variety in form, color, flavor, and consistency.

These are the requirements as set forth by Headquarters, Army Air Forces. It is highly doubtful that these same requirements can be used for other operations, particularly the foot soldier, for the size and weight requirements for an Air Force Emergency ration are very different from most others. (There is the possibility that such a ration could be dropped by the Air Force to castaways in a wide range of circumstances.) On the basis of present knowledge, a combination of food items embodying the characteristics listed above has been developed by the combined efforts of the Quartermaster Food & Container Institute for the Armed Forces and the Aero-Medical Laboratory. It is felt by many, however, that considerable improvement can yet be made in the acceptability of these food items which represent only the initial attempt at incorporating into a ration the desired characteristics. In such efforts, one is brought face to face with the too frequently unappreciated difficulty of transposing physiologic requirements into the palatable, familiar, easily-packaged, compact, stable food items that are required ultimately for use as a ration. It is gratifying to be able to state that considerable progress along this very line has been made by the Food Development Division of the Institute. Their most recently developed food items are to be presented for inspection at today's Survival and Emergency Ration Conference.

Despite the definite progress that has been made in the basic physiologic aspects of the survival problem, and the equally encouraging advances in the developmental phases, there yet remain many problems which require urgent answer. As a means of pointing up the host of details involved in "perfecting" a ration, some of the more immediate problems may be enumerated. One basic problem lies in the fact that practically all of the data obtained on human volunteers are predicated on the availability of 800 cc. of drinking water a day, while living in a temperate environment. There is, of course, no real assurance that such will be available to every castaway, and what is perhaps more pertinent, there is considerable likelihood that in the Arctic such an amount would not be available unless adequate fuel for heat, and perhaps, shelter, are provided. It is strange to conceive of lack of water in the midst of ice and snow, and yet the results of recent Arctic trials indicate that for the castaway in those regions the melting of ice would take much time and heat, particularly if he were without shelter. It is a basic premise for survival feeding that the less the available quantity of drinking water, the closer one is forced towards a pure carbohydrate ration, if renal losses of body fluid are to be kept at a minimum. With further reference to the Arctic itself, there is great need for determining the effect of cold upon survival requirements.

Certain technical questions remain which may require repeating or extending the investigative work done earlier. Thus, it would be desirable to extend the experimental periods used in order to determine the effects found during experimental periods of a few weeks; it would also be desirable to compare the relative effects upon urine volume of lactalbumen and egg protein when the former is ash-free; and possibly, additional investigation might be done on the effects of methionine when added to the diet in larger and smaller amounts. Some work is already underway in these connections.

There are other problems related to determining which combinations of protein might produce an effect upon nitrogen sparing that exceeds that found to occur when egg protein alone is used. The well-known "supplementary" value of two or more proteins used together in a diet should be exploited fully so that not only is a maximum effect obtained in the physiologic sense, but what is probably of more practical concern, so that food items may be developed without restriction as to one main type of protein. Such a restriction begets artificiality, and no artificial ration is likely to attain ultimate success.

The possibility of devising a survival ration for use in all environments is an enticing but elusive goal. There is some question as to whether or not an "all purpose" survival ration will ever be realized. It is known, for instance, that calorie requirements are much greater in the Arctic than elsewhere, due mainly to the three factors mentioned previously. This requirement could be met by more quickly using up the supply of the survival ration, but this obviously may decrease the length of time the castaway will hold out, and if the water supply were not increased commensurately, the amount of protein consumed would be in excess from the standpoint of conserving body water. Of even more immediate importance than

this, however, is the wide difference in packaging and stability requirements that characterize extremes of environment. The difficulties in the tropics would seem to be chiefly those of stability, although packaging problems there are by no means non-existent. In the Arctic, both packaging and stability are involved, in ways that may not be immediately apparent unless one visualizes the difficulties of removing packaging in the extreme cold and eating food which, although frozen when it comes into use, may have been stored previously in a heated warehouse and other supply points indoors or outdoors. The need for supplying the food in bite-sized pieces will also have to be determined, as well as the types and combinations of foods that are least thirst-provoking.

We can, however, go only so far in the laboratory toward producing a finished item that will be acceptable as the Emergency and Survival Ration. Although it is obvious that many additional research and developmental problems remain to be solved, one of the most promising directions for future progress would seem to lie in operational trials of the food items recently designed for this ration. The completion of such trials is now looked forward to as the source of critical information which will bring the Institute to the final stages of this project, and the attainment of a long sought goal. In the words of General Larkin, The Quartermaster General of the Army: "The development of a satisfactory Survival Ration is indeed an important project, for the preservation of life is not only instinctive to man, it is also of fundamental importance for successful military operation."

DR. BERRYMAN:

We will now go on to the next topic on the program, which will be presented by Dr. King, who is known to all of you as an outstanding scientist and as the Scientific Director of the Nutrition Foundation. He will speak to you briefly of the contributions that have been made to the survival and emergency ration. Dr. King.

DR. KING:

Significant Contributions to the Survival and Emergency Problem

It is unnecessary for me to review the research work that has been conducted in this field of emergency rations, because Dr. Berryman has already done that very thoroughly. Rather, I should like to comment on a few additional points related to the problems under discussion.

First, when the World War II problems were uppermost in everyone's mind, there was no adequate scientific evidence by which one could devise an emergency ration. It may seem strange, but that is true. I recall discussions in the National Research Council when we had the most able chemical, medical, and military officers that could be assembled to discuss the problem. They were dealing in theoretical terms, guessing, and no one there had an answer that was based on good experimental evidence. At one session, I recall they considered whether rum should be included in the emergency rations in Naval vessels. The fact that the British, who were certainly more experienced in naval affairs than we, had rum, led them to conclude that we were missing something. So they finally decided that the Navy should have rum in view of the British tradition; but within a week or two we received word the British had dropped it from their ration because its advantages were not supported by any good evidence! How the rum was disposed of I am not informed.

Again in a discussion of rations for aviators, one of the most competent medical authorities prepared a list of foods that aviators should eat and another list that aviators should not eat and, to my surprise and his, he had some of the same foods in both lists. You see, he was just reasoning without the benefit of experimental evidence.

If you review step by step the work done on emergency rations, you will note that during almost every six-month interval, new pertinent information was brought to light. I watched it very closely and almost every progress report that came in had new information -- information that is now basic to any final or satisfactory solution to the problem.

Again, I should like to emphasize the fact that there is still not sufficient experimental evidence by which to devise a satisfactory emergency ration. But on the basis of continuing research work there is brighter prospect of devising a good ration and it is becoming evident

that the problem is common to a great many areas of military operations. It is common to the Navy's problem of men on emergency craft; it is common to the aviation problem, since no one knows where a man is to be dropped, whether on a raft, in the arctic or in tropical desert areas. But in getting data to guide plans for such situations, the evidence points strongly toward achieving the goal of a ration that is satisfactory in nutritional requirements, meets the emergency of a limited water supply, and provides for acceptability, space density and caloric density.

The first approach to the protein problem was based chiefly upon need of protecting an individual subjected to hemorrhage, shock, or burns. The basic problem of general physiological welfare in maintaining the body protein reserve was of wide interest. The Harvard findings that weight for weight carbohydrate protected the body in regard to water supply more than water itself opened people's eyes to the fact that they had a complex but practical physiological area here to study.

The protein problem has gone through a similar cycle. There was a tendency to say, "Well, provide carbohydrate, for if you don't provide it, water and protein will be wasted anyway." Now it is evident that there is a limit to the amount that one can spare the body's reserve of water through reducing protein intake. Moreover, the caloric problem became very prominent in conjunction with the protein research.

In conclusion, it seems to me that the record shows very clearly the practical value of continuing research work of the kind that has been under discussion at this conference.

DR. BERRYMAN:

The next paper will be presented by Dr. Pearl Swanson, of Iowa State College. Dr. Swanson.

DR. SWANSON:

Utilization of Food Proteins

Our interest in the utilization and metabolism of nitrogen had its origin in a study initiated several years ago, that had to do with a determination of the nutritive value of the proteins of dehydrated eggs - a commodity at that time of strategical importance in the feeding of armies scattered all over the world. The experiment was planned to permit an evaluation of egg proteins in terms of Mitchell's classic index, biological value.

In this procedure, the rat is commonly used as the experimental animal. Measurements are made of the relative quantities of nitrogen ingested and excreted during a period of nitrogen-low feeding and in a subsequent period when a limited amount of test protein is incorporated into the diet. In comparing the excretions in the two experimental periods, workers have generally observed that the quantity of urinary nitrogen in the protein-feeding period exceeds the excretion when the low-nitrogen ration is administered. The difference between the two values represents the food nitrogen not "retained by the body for repair or construction of nitrogenous tissue", and the biological value "is calculated as the percentage of the absorbed nitrogen that is not eliminated in the urine."

However, imagine our surprise, yes, even our dismay, when the data collected in the course of rigidly controlled experiments did not permit the application of Mitchell's definition of biological value. In all cases the quantity of nitrogen excreted in the urine by rats when egg proteins were added to the nitrogen-low ration was less than that in the immediately preceding period when only the protein-free diet was fed. On the other hand, when casein, gelatin, pork muscle or the proteins of rat muscle and rat liver were tested, the heretofore expected increments occurred.

The data clearly indicated the nutritional superiority of egg proteins and suggested that these proteins were used more efficiently by the animal organism in the maintenance of essential processes than the animal's own tissues. The development of a new index to express the nutritive value of the proteins was necessary. It was called "biological efficiency", and apparently was equivalent to Allison's "nitrogen balance index" proposed independently at about the same time.

The recent great war has brought to a focus the realization that knowledge is inadequate for the intelligent feeding of men forced to live on restricted rations for any period of time. The formulation of a satisfactory "survival ration" has become an important project of the Quartermaster Corps of the Army faced with the responsibility of feeding men under emergency situations when full, well-balanced rations can not be provided. Such a ration must be able to withstand variations in environmental conditions without deterioration, prove acceptable to the consumer, and contribute toward the maintenance of normal physiological functioning of the body.

The experiments just described indicated that eggs might be particularly useful in the formulation of emergency rations. However, the problem of their inclusion was beset with complications. The introduction of eggs into a ration raised problems regarding keeping qualities, possibilities of combination with other food materials, and final acceptability of the ration. In attempts to overcome these difficulties and to reduce the monotony of survival rations, the use of other food proteins was indicated. Before steps could be taken to so enhance the palatability, texture, variety, and keeping qualities of the ration, the nutritional value of proteins that seemed suitable for the purpose needed to be established in terms of the new index.

Furthermore, it appeared desirable from the standpoint of securing additional diversity, to evaluate combined as well as single food proteins. It seemed possible that by judicious combination, a variety of proteins might be introduced into the diet that collectively would have as important a biological effect as egg proteins. The first part of the report I am to make, therefore, was specifically planned to secure information regarding the biological efficiency of as large a group of single and combined food proteins as possible.

PART I

The Nutritional Value of Various Proteins and Protein Mixtures

Pearl Swanson and Hazel Metz

Methods Used and Plan of Experiment

Interpretations of the nutritional value of the proteins and protein-mixtures studied are based upon data obtained in two consecutive balance tests. Male albino rats of inbred Wistar strain, 6 months old, were the test animals. In the first period, collections of food, feces, and urine were made over an interval of 7 days after the rat had lived on a nitrogen-poor diet for 11 days. Then the dietary modification was introduced. Four days were allowed for adjustment to the diet, after which the nitrogen balance was determined again over a 7-day period.

The basal nitrogen-low diet contained dextrin, 73 per cent; butterfat, 10 per cent, lard, 10 per cent; Osborne and Mendel salts, 4 per cent; NaCl, 1 per cent, and ruffex, 2 per cent. This ration was fortified with a mixture of pure vitamins including all known members of the B-complex, ascorbic acid and vitamin E, rice bran polish and cod liver oil.

The diet was fed *ad libitum* in the first collection period when the low-nitrogen diet was fed. In the second collection period when the test protein supplemented the ration, a quantity of food equaling the average daily intake in the first collection period was offered. The animals consumed on the average, 49 Calories per day.

In assessing the nutritional value of the specific proteins studied, their influence on the quantity of nitrogen excreted in the urine is one key that may be used. However, the data permit the calculation of other indices that give better pictures than the quantity of urinary nitrogen excreted under the conditions of this experiment.

The first, "body nitrogen spared", represents the algebraic difference between the balance characteristic of the nitrogen-low feeding period and that of the second metabolism period when the test protein is fed, *i.e.*, it is a quantitative expression showing the extent to which the negativity of the nitrogen balance on a protein-free diet is reduced under the conditions of the experiment by the incorporation of protein in the ration.

Body nitrogen spared like the nitrogen balance in the egg-feeding period bears a linear relation to the quantity of nitrogen ingested.* It is possible, therefore, to relate this value to either food nitrogen absorbed or to food nitrogen ingested. The first ratio has been adopted for the expression of nutritional value in the Iowa State College laboratory, and has been designated as "biological efficiency." An objection to the use of this index arises from the fact that the calculation of food nitrogen absorbed is based on the theoretical assumption that the excretion of fecal nitrogen of metabolic or physiological origin remains constant during the two experimental periods. That this does not always occur is illustrated by data presented herein. Note the experiments with rice. Whether such depression is of bacterial or metabolic origin has not been determined. In view of this observation, reference of body nitrogen spared to food nitrogen ingested might constitute a less complicated index than biological efficiency. This relationship has been determined in the present investigation and has been referred to as the "utilization ratio."

Three groups of experiments were conducted. In the first the nutritive values of the proteins of dried whole egg, polished rice, dried brewers yeast, and lyophilized skim milk were determined.

The results of the first experiment indicated that the proteins present in milk were considerably less efficient than those of eggs and rice. The next experiment (II) was designed to check this observation, and to evaluate the validity of the proposed indices from another experimental angle. The nutritive value of a sample of the same lot of lyophilized skim milk used in Experiment I was retested. Simultaneously, lactalbumin and casein, the principal protein constituents of milk, were studied not only singly but also combined in the proportions in which they are found in milk (casein: 90 parts; lactalbumin: 18 parts). This mixture is designated throughout the manuscript as "synthetic" milk protein.

Experiment III was suggested by the fact that a number of the individual and natural mixtures of food proteins examined were found to be of superior nutritive quality. The Quartermaster Corps of the United States Army has suggested that the acceptability of an emergency or subsistence ration might be greatly enhanced by the substitution of a mixture of protein for a single protein in its formula. An attempt was made, therefore, to combine several sources of protein in such a way that the resulting mixture would be equivalent in nutritive value to some of the most efficient proteins known. In making these mixtures, proteins of high nutritional value that lent themselves well to combinations of pleasing texture and flavor were selected. The following combinations were used;

1. a mixture of one-third egg proteins and two-thirds rice proteins;
2. a mixture of one-third egg proteins and two-thirds milk proteins;
3. a mixture of one-third egg proteins, one-third rice proteins, and one-third milk proteins; and
4. a mixture of one-half egg proteins, one-fourth rice proteins, and one-fourth milk proteins.

The milk protein represented in the above combinations was an artificial mixture being composed of pure casein** (80 per cent) and lactalbumin*** (18 per cent), i.e., synthetic milk protein.

Results

Inspection of Table 1 reveals, as in earlier experiments, that when dehydrated eggs served as the source of dietary protein in period II, the excretion of urinary nitrogen was depressed below that observed when the low-nitrogen diet was fed. The average total output in the 7-day period was decreased by 67 mg. in the first test and by 81 mg. in the second test. On the other hand, yeast, rice, or milk proteins fed in the same quantity (3.5 per cent of the total ration) seemed to introduce no marked change in the quantity of nitrogen eliminated in the urine. The changes fell within the range of variation that may occur in rats fed the low-

* Unpublished data, Files, Foods and Nutrition Section, Iowa Agricultural Experiment Station, Project 799.

** Labco casein, vitamin-free; purchased from The Borden Co.

*** Casein-free lactalbumin; purchased from Harris Laboratories.

TABLE 1. AVERAGE METABOLIC DATA OBTAINED IN 7-DAY BALANCE TESTS: RATS FED NATURAL FOOD PROTEINS IN PERIOD II

Metabolic data	Egg proteins				Rice proteins				Yeast proteins		Milk proteins****	
	Test 1		Test 2		Test 1		Test 2					
	Pd. I	Pd. II	Pd. I	Pd. II	Pd. I	Pd. II	Pd. I	Pd. II	Pd. I	Pd. II	Pd. I	Pd. II
Body wt. (gm.)	257	252	271	272	258	249	275	269	268	256	261	253
Dry food (gm.)	74	73	79	76	77	79	76	75	80	78	80	80
Calories eaten (no.)	348	350	368	365	363	350	353	327	372	360	377	370
Food N (mg.)	47	453	60	469	48	436	58	440	49	470	49	472
Fecal N (mg.)	175	184	145	185	185	147	143	138	178	248	170	214
Food Fecal N (mg.)	-	9	-	40	-	0	-	0	-	70	-	44
Urinary N (mg.)	290	223	309	228	322	312	335	316	311	329	293	317
Total N loss (mg.)	465	407	454	413	507	459	478	454	489	577	463	531
N balance (mg.)	-418	+ 46	-395	+ 56	-459	- 23	-420	- 14	-440	-107	-414	- 59
N absorbed (mg.)	-	444	-	429	-	436	-	440	-	400	-	428
Body N spared (mg.)	-	464	-	451	-	436	-	406	-	333	-	355
B.E.*(%)	-	104	-	105	-	100	-	92	-	83	-	83
C.D.**(%)	-	98	-	92	-	100	-	100	-	85	-	91
U.R.***(%)	-	102	-	98	-	100	-	92	-	71	-	75

*Biological efficiency
**Coefficient of digestibility
***Utilization ratio
****Lyophilized milk

nitrogen diet (mean excretion of 290 rats, 291 mg.; standard deviation, 44 mg.)*. It should be noted that in the two experiments in which the nutritive value of rice proteins was studied, the trend was toward a depression of urinary nitrogen; while with the yeast and milk proteins there was a tendency toward an elevation in nitrogen excretion.

As explained above, the percentage relationship of body nitrogen spared to food nitrogen absorbed is biological efficiency. Egg proteins in the first test thus received a value of 104 and in the second test, 105. The two values obtained for rice proteins were 100 in Test 1 and 92 in Test 2. The fact that the rice tested was purchased in two lots may explain the difference in results. Yeast and milk proteins both had average values of 83.

The index, utilization ratio, presents the total picture of protein utilization. The average utilization ratios of the various food proteins were: eggs, 102 and 98; rice, 100 and 92; yeast, 71; milk, 75.

In the second part of this unit of the investigation, the results obtained in Experiment I were evaluated. Table 2 presents the metabolic data and the nutritive indices determined in this experiment. By comparing the urinary nitrogen excretions resulting from the incorporation of these proteins into the basal non-protein diet in quantities equivalent to 3.5 per cent of the ration, it is seen that lyophilized milk and synthetic milk proteins both gave rise to a slight increase in the excretion of urinary nitrogen, the quantity of body nitrogen spared by the various sources of milk proteins was greatest for lactalbumin, i.e., 457 mg., as compared with 324 mg. for lyophilized milk, 361 mg. for synthetic milk proteins; and 312 mg. for casein.

The biological efficiencies for lyophilized milk and for synthetic milk protein were both 83. This was also the value obtained for lyophilized milk in Experiment I. Lactalbumin and casein similarly evaluated received ratings of 106 and 72, respectively. Thus, the value for the mixture of proteins found in milk is intermediate between the values obtained for its constituents, lactalbumin and casein, being related to the approximate proportions of each protein present.

The results obtained in Experiment III when various protein combinations were tested are shown in Table 3. When the figures representing the quantity of urinary nitrogen excreted in the two metabolism periods are inspected, it is seen that there is a decrease in its excretion after the ingestion of each of the mixtures.

The relative quantities of body nitrogen spared by the various protein combinations were: egg and rice, 432 mg.; egg and milk, 365 mg.; egg, rice and milk (one-third each), 438 mg.; and egg, rice, and milk (one-half egg), 402 mg. These figures seem to indicate that the proteins of the egg and rice combination were well utilized.

The relative nutritive worth of mixtures containing one-third egg and two-thirds rice proteins; one-third egg and two-thirds milk proteins; one-third egg, one-third rice, and one-third milk proteins; and one-half egg, one-third rice, and one-fourth milk proteins was evaluated in terms of the indices reported below:

1. The biological efficiencies obtained for these combinations were 98, 94, 104, and 101 respectively.
2. The respective utilization ratios were 98, 85, 99, and 97.
3. The coefficients of digestibility were 100, 91, 96, and 96 respectively.

These data show that proteins lending themselves for use in survival rations may be so combined as to yield mixtures that approach egg proteins in nutritive value.

* Unpublished data, Files, Foods and Nutrition Section, Iowa Agricultural Experiment Station, Project 799.

TABLE 2. AVERAGE METABOLIC DATA OBTAINED IN 7- DAY BALANCE TESTS: RATS FED MILK PROTEINS FROM VARIOUS SOURCES

METABOLIC DATA	Lyophilized milk proteins		Synthetic milk proteins*		Lactal-bumin		Casein	
	Pd. I	Pd. II	Pd. I	Pd II	Pd. I	Pd.II	Pd. I	Pd. II
Body wt. (gm.)	284	274	276	271	265	259	272	263
Dry food (gm.)	76	74	80	77	80	78	76	74
Calories eaten (no.)	358	336	372	350	377	360	353	341
Food N (mg.)	59	428	61	445	49	460	58	459
Fecal N (mg.)	150	186	167	179	164	192	154	178
Food fecal N (mg.)	-	36	-	12	-	28	-	24
Urinary N (mg.)	309	318	331	342	300	226	311	376
Total N loss (mg.)	459	504	498	521	464	418	465	554
N balance (mg.)	-400	76	-437	- 76	-415	+ 42	-407	- 95
N absorbed (mg.)	-	392	-	433	-	432	-	435
Body N spared (mg.)	-	324	-	361	-	457	-	312
B.E. (%)	-	83	-	83	-	106	-	72
C.D. (%)	-	92	-	97	-	94	-	95
U.R. (%)	-	76	-	81	-	99	-	68

*A combination of casein and lactalbumin in the proportions in which they are found in milk.

TABLE 3. AVERAGE METABOLIC DATA OBTAINED IN 7-DAY BALANCE TESTS: RATS FED VARIOUS MIXTURES OF FOOD PROTEINS

Metabolic data	1/3 Egg 2/3 Rice		1/3 Egg 2/3 Milk*		1/3 Egg 1/3 Rice 1/3 Milk		1/2 Egg 1/4 Rice 1/4 Milk	
	Pd. I	Pd. II	Pd. I	Pd. II	Pd. I	Pd. II	Pd. I	Pd. II
Body wt. (gm.)	272	265	281	275	278	274	268	262
Dry food (gm.)	74	75	75	73	71	70	69	68
Calories eaten (no.)	348	338	353	343	328	319	325	319
Food N (mg.)	58	442	58	430	56	442	55	415
Fecal N (mg.)	164	151	143	183	144	163	145	161
Food fecal N (mg.)	-	0	-	40	-	19	-	16
Urinary N (mg.)	310	275	321	288	327	256	327	269
Total N loss (mg.)	474	426	464	471	471	419	472	430
N balance (mg.)	-416	+ 16	-406	- 41	-415.	+ 23	-417	- 15
N absorbed (mg.)	-	442	-	390	-	423	-	399
Body N spared (mg.)	-	432	-	365	-	438	-	402
B.E. (%)	-	98	-	94	-	104	-	101
C.D. (%)	-	100	-	91	-	96	-	96
U.R. (%)	-	98	-	85	-	99	-	97

*"Synthetic" milk protein used in all combined protein mixtures.

PART II

Dietary Fat and the Nitrogen Metabolism of Rats Fed Protein-Free Rations

Pearl Swanson, Wanda Willman, Miriam Brush, and Helen Clark

An important event in the history of the science of nutrition occurred at the time when emphasis in research shifted from investigations dealing with the utilization and the metabolism of the proteins, carbohydrates, and fats to studies of the "importance of the little things in nutrition." All of us know of the interest that accompanied the identification, one by one, of these essential dietary components, and how our ideas of the adequate diet grew and developed. In its formulation, many of the basic concepts of the old masters regarding the role of the major foodstuffs were accepted. Perhaps it is because the characteristics of an adequate diet are defined more clearly today than they ever have been before that research workers in nutrition are learning that the metabolic pathways of these common nutrients may take unexpected turns and deviations. This has been the experience in our laboratory. Some of the enthusiasm of the famous workers in the old German laboratories has been recaptured and it has not been difficult to imagine how Carl V. Voit felt when he wrote, according to Lusk's translation, "Imagine our sensations as the picture of the remarkable processes of the metabolism unrolled before our eyes, and a mass of new facts became known to us!" The data I am about to present make only a small contribution, but they do indicate the complexity of the processes governing protein, fat, and carbohydrate metabolism and the remarkable adjustments that the body, under stress, can make.

Experiments of the kind just reported suggested that the way of handling the data obtained in the classic balance test might become an important instrument for studying the course of nitrogen metabolism under various conditions. In thus using the balance test, we came to examine the nitrogen exchange when variations in the energy value of the ration, both quantitative and qualitative, were introduced.

The experimental plan described in Part I was again used. Standardized animals were observed in a period when a nitrogen-poor ration only was fed, metabolic materials being collected for the estimation of nitrogen balance. Then the dietary adjustment was made, and nitrogen balance determined again after an appropriate adjustment period. Metabolism in the two periods was then compared.

In the first experiment to be reported, two basal protein-free rations were used: one, rich; the other, poor in fat. One, which shall be designated hereafter as the high fat ration, contained 20 per cent of fat, made up of equal parts of butter fat and lard. The other, the low fat diet, contained no fat except that present in the two drops each of the Wesson and cod liver oils fed daily. Each diet was supplemented with a synthetic mixture of known vitamins fortified with ricebran polish extract. The respective energy values of the two diets were 4.8 and 3.8 calories per gram. The two series of rats receiving these diets voluntarily adjusted their food consumptions so that the average caloric intake in each series was 49 calories per day.

In the first experiment, the effect of restricted energy intake on the nitrogen metabolism of the two test series of rats fed the two protein-free rations was studied. The various groups making up the experiment are shown in Table 4. I shall speak of the group fed the protein-free diet high in fat as Series I, the group given the similar diet low in fat as Series II. Each series was made up of 24 rats. The respective diets were fed ad libitum in the preliminary and collection periods of the first balance test. Then each series was divided into 4 groups. Food was offered in such quantities to these groups that the caloric consumption of each series was maintained at 4 different levels. The quantity of food to be supplied to each animal daily was determined by dividing the total quantity of food consumed in the first metabolic period by seven and offering either this full amount or 3/4, 1/2, or 1/4 thereof as the daily quota. Thus, the intake of every rat in the second test period was controlled by its intake in the previous collection period. The table shows that this experimental manipulation gave for the 4 groups of each series average caloric intakes that bore the general relation to each other as 4:3:2:1.

Because every rat served as its own control, and because the plane of nitrogenous

TABLE 4

Average caloric intake per day of rats fed basal low nitrogen diets

Percent of normal intake of Calories supplied by daily food	High fat diet Series I		Low fat diet Series II	
	Period I*	Period II	Period I*	Period II
	Cal.	Cal.	Cal.	Cal.
100	47	46	51	49
75	47	35	48	36
50	51	25	47	23
25	54	13	48	12

*Food offered ad libitum

metabolism was comparable in all animals in Period I, it was possible to measure the effect of caloric restriction on nitrogen metabolism by comparisons, first, of changes in excretion of nitrogen from Period I to Period II; and second, by comparisons of the character of the nitrogen exchange in the second balance period of each dietary group.

Average data depicting the quantities of nitrogen excreted in the urine by the 8 test groups in the two balance periods are presented in Table 5. In column I under each diet heading in the table appear the average quantities of urinary nitrogen excreted in period I when food ad libitum was allowed; in column II, the amounts eliminated in period II when the limitations on caloric intakes were imposed. In the third column, headed Difference, are the data that show the effect that the dietary manipulation had on the urinary excretion.

Differences in the total excretions of nitrogen in Period I from group to group and from series to series are not significant. When the high fat diet was fed, an increase in the quantity of urinary nitrogen excreted in Period II occurred with each successive reduction of calories, thereby giving a measure of the extent to which the animal was forced to draw upon its own tissues for its energy needs as the caloric value of the ration decreased. For example, reducing the caloric intake of the animal to 1/4 its normal ingestion, caused an increase in the quantity of nitrogen excreted over that of the previous period of 254 mg.

Inspection of the data showing the response of the rats given the low fat diet indicates that its administration profoundly affected the pattern of metabolic processes, particularly at the two lower levels of caloric intake. For example, 818 mg. of nitrogen were excreted in Period II by the "25% calorie" rats. This figure converted to its equivalent of body tissue indicates that these rats lost 27 gm. of body weight in the second balance test. The actual weight loss as averaged from laboratory records was 28 gm. in this interval; 19 gm. of this weight loss can be ascribed to the reduction in the food quota. On the other hand, like restriction of calories, when fat was in the diet, brought about a loss in body weight of only 9 gm. Thus, an intensification of catabolic processes induced by the caloric restriction of the low fat diet is apparent.

Nitrogen balance gives a better picture of nitrogenous metabolism than does excretion alone. The feeding of the low fat diet at the two lowest levels of caloric intake resulted in negative nitrogen balances of 325 and 425 mg. for example, while similar reduction of calories as provided by the high fat ration resulted in negative balances of only 150 and 275 mg. respectively.

The picture is so striking that it may be pertinent at this point to recall that certain dietary patterns, here represented experimentally, had their counterparts in feeding practices created by the demands of the World War and its aftermath. I am thinking particularly of the nutritional problems of the starving masses in war-ridden countries, of the underfed groups in prison camps, and of men of the military existing for days on survival rations. It may be interesting to note in passing that the Life Raft Ration furnished by the Army in the recent war bore a marked similarity, quantitatively and qualitatively, to the low-calorie diet containing no fat used in these experiments.

TABLE 5

Average excretion (in mg.) of urinary nitrogen in 2 successive 7-day metabolism periods when protein-free rations are fed at 4 levels of caloric intake

% of normal intake of Calories supplied by daily food in Period II	High fat diet			Low fat diet		
	Period I	Period II	Difference	Period I	Period II	Difference
100	295	210	- 85	280	185	- 95
75	310	263	- 47	272	211	- 61
50	265	289	+ 24	283	594	+311
25	290	544	+254	249	818	+569

These data raised the question, if fat is needed, how much is needed? Is there a critical level below which the rate of nitrogen metabolism is increased? The next experiment was designed to test this point. Rations were made in which either 20, 15, 10, 5, or zero per cent of fat were incorporated. The rations were fed as before at the four levels of caloric intake, 120 rats being used. The removal of 5 per cent of fat from the diet produced no great change in nitrogen metabolism. But, thereafter, the picture altered. Ten per cent of dietary fat was protective when one-half the needed calories were supplied but not when their intake was again decreased. Five per cent of fat in the diet seemed to exert no protective action on the conservation of nitrogen when the calories supplied were only one-fourth normal.

In surveying the results of these experiments, earlier studies were recalled in which a marked body-sparing action of methionine had been observed when it supplemented the high fat ration. How would it function under the dietary conditions of the present experiment? The amino acid, therefore, in a quantity equivalent to 4 mg. of nitrogen per day was offered to rats at the beginning of the second metabolism period, thereby supplementing the test rations at the four calorie levels. The 20 percent fat and the zero per cent fat diets only, were used in this experiment. At the three highest levels of caloric intake, the administration of methionine with the high fat diet caused a reduction in the quantity of nitrogen excreted in Period II, both in relation to Period I and in relation to Period II in the control rats receiving no amino acid (Table 6).

The data show also that the same phenomenon occurred when the low-fat diet was fed except that it was more marked than when the high-fat diet was used when the calories were reduced one-half or more. For example, with a 50 per cent caloric restriction, the supplementation of the low-fat diet with methionine prevented the loss of 302 mg. of nitrogen (594 mg. - 266 mg.). At the 25 per cent level of caloric intake the increased catabolism is represented by an increase of 254 mg. of urinary nitrogen. This jumps to 569 mg. when fat is removed from the ration. The significant point is that the supplementation of the diet with 4 mg. of methionine nitrogen decreases the catabolism so that it proceeds at about the same rate as when the ration contained 20 per cent of fat (compare total excretions in Period II of 544 mg. and 577 mg.).

Forbes, Swift, and their coworkers at the Pennsylvania State College have presented some extremely interesting work recently dealing with the effect of food fat on the efficiency of utilization of food energy. It seems that we, too, from a different experimental angle may be demonstrating that the action of fats in decreasing the specific dynamic action of proteins, in this case tissue proteins, leads to a retention of protein. Certainly there is evidence that under the conditions of the present experiment, fat and carbohydrate are not interchangeable in the diet, according to their metabolizable energy values - the isodynamic law of Rubner. That fat may have dietary qualifications beyond those ascribed to it at present is indicated. Perhaps - too, methionine in inducing nitrogen retention may act through its depression of specific dynamic effects.

TABLE 6

Excretion of urinary nitrogen by rats fed a basal protein-free diet and the same diet supplemented with methionine before and after dietary restriction of calories

% of energy requirement ingested in Period II	High-fat diet (20%) I	II		Low-fat diet (0%) I	II	
	Basal Urine N - calories adequate	Urine N following calorie restriction	Difference	Basal Urine N	Urine N following calorie restriction	Difference
Basal low nitrogen diet only						
100	mg./7 da.	mg./7 da.	mg./7 da.	mg./7 da.	mg./7 da.	mg./7 da.
100	295	210	- 85	280	185	- 95
75	310	263	- 47	272	211	- 61
50	265	289	+ 24	283	594	+311
25	290	544	+254	249	818	+569
Basal low nitrogen diet supplemented with 4 mg. of methionine						
100	315	188	-127	295	177	-118
75	310	215	- 95	270	204	- 66
50	298	256	- 42	257	266	+ 9
25	329	523	+194	281	577	+296

DR. BERRYMAN:

Developmental work at the Institute on the Air Force Emergency Ration has resulted in the preparation of a number of food bars. Arrangements have been made to present samples of these bars to you at this time. It is requested that you record your rating of these bars on forms to be provided when you examine the samples. A report on these ratings will be given later today. I would like to present to you Dr. Dove of the Food Acceptance Branch of the Institute who will explain how your judgments should be recorded. Dr. Dove.

DR. DOVE:

Mr. Chairman, ladies and gentlemen: In the next few minutes you will have an opportunity to test 14 of the food bars that have been developed in the commodity branches of the Institute and proposed as possible components of the Air Force Emergency Ration. The acceptability test we wish to conduct today may be conduct today may be considered the fifth in a series of tests. Perhaps there will be 10 or 15 more tests on the acceptability of these bars while their stability is being investigated. Furthermore, we will not consider acceptability testing completed until a test has been made on an actual seven-day consumption period to determine the effect upon thirst.

We are pleased to have today an opportunity to secure the candid taste judgments of these officers and professional men who are so much interested in the type of ration that is wanted.

Samples of 14 bars, each separately wrapped in waxed paper and coded, will be presented in this test. The bars will be given to you in three groups, first five, then another five, then four. Each tester will have three rating sheets -- one for each group of bars. (See Figure 1). We would like you to taste all samples within each group, then insert their numbers in order of preference on the sheet to indicate which of the group you like best, which next, and so on. Then in the column under each code number we would like you to rate each sample on a scale of 1 to 10 points. A descriptive term appears on the sheet for each numerical rating. For instance, "7" is described as "slightly off", to describe a sample

Organoleptic Test for ______________________

Name: ______________

Date : ______________

Place Samples in order of preference on rating scale, and describe differences:

	1st Choice:	2nd Choice:	3rd Choice:	4th Choice:	5th Choice:	6th Choice:
Acceptable						
10. Excellent						
9. Very Good						
8. Good						
7. Slightly off						
6. Off, but acceptable						
Not Acceptable						
5. Slightly undesirable						
4. Definitely undesirable						
3. Unpleasant						
2. Very unpleasant						
1. Repulsive						

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Fig. 1

which does not quite meet an individual's standards for any characteristic, such as color, flavor, texture, or appearance. Finally you are asked to make comments on both favorable or unfavorable characteristics of each bar, giving criticisms on flavor, taste, odor, texture, potential thirst-provoking properties, satiety value, etc. When completed the record blanks will be taken up for calculating the results. These will be compared with previous results and reported to you this afternoon.

Louise Seiter, technologist in the Food Acceptance Branch, will take charge now in the presentation of the samples with the assistance of other members of the Branch.

Distribution of Samples.

Intermission

DR. BERRYMAN:

We will resume our meeting now. The next paper will be presented by Dr. J. B. Allison of Rutgers University. Dr. Allison.

DR. ALLISON:

The Utilization of Proteins

One of the most common methods of evaluating dietary proteins is to determine the minimum amount of nitrogen necessary to maintain nitrogen equilibrium in an animal. This minimum amount of nitrogen, however, is not a constant for any one protein but varies according to the physiological state of the animal. If, for example, the protein stores are great, more nitrogen is needed to maintain nitrogen is needed to maintain nitrogen equilibrium than when the stores are low. Thus, less nitrogen is necessary to maintain equilibrium in a protein-depleted than in a normal animal. The minimum amount of nitrogen needed to maintain equilibrium varies even in normal animals and is not a constant characteristic of dietary proteins. For that reason, we have used the concept of nitrogen balance index to determine the nutritive value of proteins. This index is the rate of change of nitrogen balance with respect to the nitrogen intake at any given intake. It is a measure of the efficiency of dietary nitrogen in maintaining equilibrium; it is a function of the amount of nitrogen retained in the body of the animal. The nitrogen balance index in the region of negative balance is constant in the normal animal and characteristic of the protein fed.

Nitrogen balance indexes, varying from .35 to 1.5 have been determined in dogs, each index being characteristic of a protein source. The higher the index the better the nitrogen economy in the animal. The change in economy with the change in patterns of amino acids is illustrated by the following indexes determined before and after supplementation of a protein with an amino acid. Casein has a nitrogen balance index of 0.8; supplemented with methionine this index is increased to 1.5. A fibrin hydrolysate has a nitrogen balance index of .62; supplemented with methionine the index is increased to 1.2. The index of wheat gluten is 0.4; supplemented with lysine the index is increased to 0.8. Thus, the index does reflect changing amino acid patterns. Indexes greater than unity demonstrate body-sparing action by dietary protein. But the magnitude of the nitrogen balance index is affected by the physiological state of the dog and the caloric intake as well as the pattern of amino acids. Casein fed to protein-depleted dogs, for example, has a nitrogen balance index of .93 which is higher than the 0.8 found in the normal dogs. Casein fed to a normal dog but with 25 percent of an adequate caloric intake has a nitrogen balance index of 0.3. The remainder of this disucssion is oriented toward these factors which affect nitrogen balance indexes and the utilization of proteins by the animal.

A reduction in the caloric intake below optimum increases the excretion of body nitrogen but does not alter the nitrogen balance index until the intake is less than 50 percent of normal. When the caloric intake is less than this there is a very rapid reduction in the value of the index to zero. A reduction in urine volume accompanies the decrease in calories. A normal 10 kg. dog, for example, will excrete approximately 200 ml. of urine per day. When the caloric intake is reduced to 25 percent of the normal the volume of urine drops to about

50 ml. per day. This fall in urine volume is a result, in part at least, of reduced fluid intake. When egg white nitrogen is added to the diet and calories restricted, urine volume increases. Since the nitrogen balance index of the egg white is practically zero under these conditions, the increase in urine volume is the result of a need to excrete larger amounts of waste nitrogen. Given sufficient calories, on the other hand, the egg white nitrogen is completely retained and there is no effect on urine volume, provided the animal is not put too far in the region of positive nitrogen balance. To summarize the effect of caloric intakes on the index, when the non-protein calories are reduced systematically, two types of responses are encountered. In the first type, where the caloric reduction is relatively small, the nitrogen balance index remains essentially constant. The utilization of dietary proteins is not altered by this small reduction in caloric intake. There is, however, an increase in the excretion of body nitrogen. In the second type, where a more severe caloric restriction is imposed, that is, where the intake is less than 50 percent of adequate, there is a marked decrease in the nitrogen balance index, demonstrating a poor utilization of nitrogen.

Studies on the supplementation of casein with methionine in the dog have demonstrated that proper supplementation with methionine conserves both body nitrogen and body sulfur. This conservation is marked in the region of negative nitrogen and sulfur balances where the animal is in a somewhat depleted state. Conservation of nitrogen and sulfur becomes less marked and disappears in the region of positive nitrogen balance where the animal becomes saturated with methionine and the growth processes are not as general. Thus, methionine is a very valuable supplement to casein and to other proteins lacking optimum amounts of methionine, particularly when the animal is in negative nitrogen balance or in a protein depleted state. Excess methionine produces a pattern of amino acids, however, that is toxic. When excess methionine is added to casein the excretion of nitrogen is increased rather than decreased, body tissues being torn down, possibly due to internal supplementation of the abnormal pattern of amino acids. Even though the nitrogen excretion is increased and the body tissue nitrogen in general is being torn down, the liver protein concentration is being built up in these animals to concentrations above normal. Under these conditions of excess methionine certain globulin fractions of blood are also increased above control values. Thus, patterns of amino acids can bring about the building up of one type at the expense of other types of tissue proteins. A pattern of amino acids deficient in one of the amino acids fed to a protein-depleted dog may bring about good regeneration of plasma proteins but that regeneration is at the expense of other tissue proteins, the deficient pattern of amino acids being supplemented from tissue proteins which are depleted during this process.

Studies on protein-depleted dogs demonstrate that different patterns of amino acids will do different jobs in regenerating tissues in these animals. Even excellent proteins like lactalbumin and casein will do different jobs. Lactalbumin favors, for example, the formation of the albumin fraction, whereas casein brings about an abnormal increase in the beta globulin fraction of plasma. Other proteins, with what is generally considered poor patterns of amino acids, give excellent results in regenerating certain plasma protein but are very poor, indeed, for the regeneration of other tissue proteins. One of the best patterns of amino acids which we have found for the job of regenerating all types of tissue proteins in the animal is found in the mixture of proteins of whole egg.

Thus, the study of protein utilization has two major phases, one of these being the effect of the pattern of amino acids on the job that can be done in the animal and the other being the effect of the physiological state of the animal on the utilization of this pattern of amino acids. It is our purpose to continue our studies on these two phases including in our researches a third phase, the effect of other dietary constituents such as the vitamins, fat calories, etc., on the utilization of proteins.

DR. BERRYMAN:

There is one more paper to be presented before lunch. It will be presented by Dr. David Schwimmer of New York Medical College, Welfare Island, New York City. Dr. Schimmer.

DR. SCHWIMMER:

Recent Findings on Project, **Protein Metabolism Studies on Reduced Caloric and Water Intakes**

Dr. Berryman, ladies and gentlemen, the excellent presentations this morning by Drs. Berryman, Gelman, Swanson, and Allison have provided a clear background picture of the problems with which we are all mutually concerned. It is quite apropos to mention here that our own progress has been materially aided by the grand coordinating activities of Dr. Lepkovsky, who established a very firm liaison between our group and those of Drs. Swanson and Allison, and the unstinting advisory aid of Dr. King, who, it must be remembered, helped to initiate our studies.

Without being repetitious, I should like briefly to review some of the high points in the progress of our experiments at the New York Medical College. We have been working on survival rations since 1945. All our studies have been with human beings, for whom, in the final analysis, these survival rations are intended. Until the end of 1946 our subjects were conscientious objectors; since then we have utilized volunteer Army enlisted men from Camp Lee in Virginia.

The basic plan of each experimental run has included:

1. A standardization period of 7-10 days, during which the subjects are fed a full diet of standard Army 10-in-1 rations and unlimited water.

2. A deprivation or testing period of 10 days, during which the men are fed only an experimental ration in restricted quantity, and 800 cc. water daily. (In our very first experiment only was the deprivation period five days long.)

3. An observed recovery period of 5 days, during which the subjects again receive a full complement of food and water.

We have generally employed two to three groups of 4-6 men each, testing as many as 16 men at a time. The paired-run technique has been utilized, with a control group run in parallel with other test groups. For example, one group on a protein-free diet always accompanied other groups receiving isocaloric diets with varying quantities of protein. To date we have tested and studied 48 different experimental rations.

As indicated by Dr. Berryman, our first observations concerned themselves with the minimal caloric levels that might be required to produce nitrogen utilization and its accompanying decreased urinary volume. Initially we tried 400 calories daily, the level supplied by the standard Air Corps Life Raft Ration. This resulted in no retention whatever of the nitrogen fed.

Then we jumped to 900 calories. This figure was chosen on the basis of Dr. Swanson's work indicating that 50% or more of minimal daily requirements should be fed; 900 calories supplies this minimum if we figure the average 65-70 kg. man as having a 1500-1800 calorie daily basal expenditure. Again, however, there was no significant retention. Similar results were noted with 1200 calories. It was not until we hit 1500 and 1800 calories that a distinct improvement occurred in nitrogen utilization, with decreased total urinary nitrogen and urinary volume.

This high level of minimal caloric requirement to produce nitrogen retention would mean quadrupling the standard daily Lift Raft Ration, a consideration of great importance in the light of the strict limitations of weight and space allotments in aircraft. Therefore methionine supplementation was tried. As Dr. Berryman has told you, in contrast with the results of Drs. Swanson and Allison with rats and dogs, respectively, our human subjects not only did not show any improvement in nitrogen metabolism, but actually appeared to be somewhat worse off than without methionine. Our observations were made at the 900 and 1800 calorie levels, with diets containing 0.0, 3.0, and 6.0 gm. nitrogen, respectively. The laboratory results accruing from supplementation with methionine can be summarized as follows:

1. An increase in total urinary nitrogen
2. An increase in urinary urea nitrogen
3. An increase in urinary volume
4. An increase in total urinary solutes
5. An increase in urinary ammonia nitrogen
6. An increase in the negative nitrogen balance
7. A decrease in serum potassium concentration
8. An increase in urinary potassium

The unfavorable effect of methionine on nitrogen metabolism here seems best explained by a possible species difference. It has been suggested, especially on the basis of Dr. Allison's observations, that we may have used too much methionine. However, if we recall that Leon Miller in his work on dogs used 0.1 gm. methionine per kg. body weight, then our 2.5 and 5.0 gm. supplements for 65-70 kg. men do not seem to have been excessive. Nevertheless, I believe that Dr. Allison's experience justifies repetition of our studies at a later date using 1.0-1.5 gm. methionine.

In accordance with the suggestion of Dr. Chaikoff, we next studied the effect of periodicity of feeding. Three groups of four men each were fed identical 900 calorie rations supplying 3.0 gm. nitrogen. One group ate the whole ration at 9 A.M.; another group ate it in four feedings, at 9 A.M., 1 P.M., 5 P.M., and 9 P.M.; the third group ate the ration in 12 hourly installments from 9 A.M. to 9 P.M. No demonstrable difference was observed with the different regimens. The same experiment was repeated at the 1200-calorie level, and here the single-feeding group appeared to be somewhat better, but the results cannot be stated to have been statistically significant.

Although the greatest portion of our work has utilized dehydrated egg white as the source of protein nitrogen, some work has been done with other types of protein. The results, briefly, indicated that dehydrated egg white is markedly superior to protein derived from malted milk and to lactalbumin. With respect to lactalbumin, however, it must be said that the product we had contained almost 9% ash, and probably does not represent the optimal lactalbumin available. Further observations on lactalbumin and casein are indicated.

Another aspect of the survival rations problem which is of great importance is the question of caloric output. This is especially of major concern in arctic areas, where the intense cold required the expenditure of large quantities of energy to maintain body temperature and heat inspired air. We had originally entertained the notion that Dr. Swanson's previously mentioned "50%-of-caloric-requirement" minimum might apply to total caloric expenditure, rather than to basal caloric expenditure; this idea was strengthened by our failure to obtain improved nitrogen utilization below 1500 and 1800 calories. Therefore we tested two groups of men at 1800 calories. One group was ambulatory in the Research Unit ward, according to our usual procedure. The other group marched 12 miles daily at four miles per hour, thereby expending an additional 600-700 calories. We were indeed surprised to find the nitrogen picture about the same in both groups.

Thinking that perhaps the 600-700 calorie increment in energy output had been insufficient to produce a sufficiently great difference, we followed the suggestions of Dr. Herbert Pollack, whom I see here in the audience today. He advised, on the basis of his own studies at Camp Lee during the war, that our exercising group march with full 35-pound pack at the rate of three miles in 50 minutes, then rest 10 minutes to avoid building up an oxygen debt. In this fashion, each man would expend an additional 100 calories per mile. Following this procedure, our exercising group marched 15 miles daily for 10 days, expending a calculated additional 1500 calories each day over the amount used by the men in the control group. In this experiment, too, there was no detrimental effect upon nitrogen utilization; if anything, the exercising group did perhaps a shade better than the control group. Perhaps the explanation for this phenomenon resides in a phasic effect of exercise. Every clinician knows that the patient at absolute bed rest loses nitrogen rapidly. A moderate amount of exercise improves the nitrogen metabolism, possibly by better tapping of reserve body depot fat for calories (cf. exercise in diabetics).

Extreme degrees of exercise, carried out over long periods of time, will probably have a detrimental effect, especially when depot fat is exhausted. It is very evident that further studies must be made on this problem.

At this point, it is appropriate for us to return to the studies I described earlier at the various caloric levels from 400 to 1800 daily. In those experiments, the daily ration supplied 3.0 gm. nitrogen, derived from 20.0 gm. dehydrated egg white. Since even at the beneficial 1500 and 1800 calorie levels, the daily total urinary nitrogen excretion averaged 5.0 - 6.0 gm., it was decided to increase the daily intake of nitrogen to 6.0 gm. in an attempt to attain positive nitrogen balance. That this occurred at the 1800 calorie level was not too surprising, but we were certainly not prepared for the excellent nitrogen retention observed when only 900 calories daily were fed. Repeated studies corroborated this, and it appears that a simple increase in the amount of nitrogen fed enhances the efficiency of nitrogen retention, even at low calorie levels.

About the same time, we undertook studies on the effect of varying quantities of fat. All the aforementioned caloric observations had been made on diets containing 10% hydrogenated fat by weight. It was felt that if the content of fat could be increased, the highly desirable objective of increased caloric density might be attained. Accordingly we tested three groups of subjects in parallel, feeding them all 900 calories, but with the content of fat in the diets at graded levels of 10%, 20%, and 30%, respectively. All three levels of fat--even the 30%--were taken for 10 days with no signs of digestive disturbance. This was contrary to our experience early in 1945, when two subjects fed a ration with 25% fat suffered from nausea, abdominal discomfort and cramps. The probable explanation for the difference in gastrointestinal tolerance seems apparent now: in the more recent studies the fat was well mixed in the ration, whereas in the earlier work the fat had "bled out".

The demonstration that the digestive tract could tolerate 30% fat by weight in a ration not designed with an eye to palatability was not, however, the only result of this experiment. It also developed that the 30% fat ration--in contrast with the 10% and 20%--distinctly decreased urinary nitrogen excretion and urinary volume. When we recall that the three test rations were isocaloric, it becomes evident that the nitrogen-sparing effect of 30% fat was not due to increased calories, but rather to something intrinsic in the higher fat intake per se.

From a very realistic and practical standpoint then, these data I have given you mean that we have accumulated here the basis for suggesting a new survival ration. This ration, supplying 900 calories, containing 6.0 gm. nitrogen and 30% fat by weight, weighing about 180 gm., has maintained positive nitrogen balance, decreased urinary nitrogen, solutes, and volume, and kept the subjects in good clinical condition.

It is necessary that such a ration undergo further laboratory trial and study. Also, it is extremely desirable, especially if it be projected as an overall all-purpose survival ration for all the Armed Forces instead of just the Air Corps, that this ration be tried over a deprivation period longer than the 10 days so far used. Certainly the stresses and strains applying over a long term differ from the short term, when much of what occurs may depend upon a carryover from the normal control state. To this end, we have set up an experiment to test this ration for a 40-day period. If the results approach those obtained to date in 10 days, we shall consider that real progress has been made.

Time does not permit discussion now of various other data we have obtained on electrolyte balance, blood sugar levels, urinary 17-ketosteroid excretions, and other endocrine findings. These will appear in forthcoming reports.

In closing, I should simply like to stress very strongly that the type of basic research reported here by the several investigators must be continued, since there are still many areas where our physiological knowledge is extremely deficient. I would add, further, the plea that close liaison be maintained among the investigating groups for optimal results. Thus there can be a beneficial interchange of ideas by men all working towards a common goal.

DR. BERRYMAN:

This concludes the morning session of this conference. For the afternoon session we will re-convene in this room after lunch.

Luncheon

(AFTERNOON SESSION)

Developmental Aspects of Survival and Emergency Rations

DR. BERRYMAN:

This morning our discussion pertained to the research aspects of the survival ration. This afternoon we would like to review some of the developmental phases that have been worked on in the Institute laboratories. The chairman for this afternoon will be the present Director of Food Laboratories at the Institute, Dr. Howard D. Lightbody, who was formerly with the Food and Drug Administration and later with the Western Regional Research Laboratory of the Department of Agriculture. It is a pleasure to present Dr. Lightbody.

DR. LIGHTBODY:

The morning's part of the program was devoted to a report on the more recent advances in the basic sciences underlying specifically the survival ration development. Now we turn our attention to the development side. First, you must have been very much impressed with the complexity of the problem insofar as the basic sciences are concerned. The development man has to be cognizant of these results because it is his duty to apply them to the specific problem at hand. He knows the terms "biological value" and "caloric density", he knows something of the interrelationships of carbohydrates, fats, and proteins; perhaps he must know something of the biological value of proteins in order to select the proteins that go into a ration. I suspect that most of the development people are very grateful that at the moment at least a vitamin requirement has not been introduced into this particular ration.

The development people of course must go much farther than the mere nutritional studies or the physiological studies. They must in their formulation know the acceptability of the product that is produced, and at times what appear to be some very excellent ideas turn worthless after they reach acceptability testing. They must consider availability of raw materials, and they must be assured in formulation of their products that they are not presenting something that is not feasible to process. And then they must consider the stability or keeping quality of the product.

Recently the development work in the Institute has been under the direct supervision of Dr. Fevold, and he and his group have been instrumental in bringing the development to the state that is represented by the ration that was presented to you this morning for your examination and expression of acceptance. Dr. Fevold will discuss for you the present state of emergency ration development in the Institute. Dr. Fevold.

DR. FEVOLD:

Discussion of Survival Ration and Emergency Food Items Recently Developed

This morning we heard about the physiological aspects of survival nutrition and how our ideas have changed from those which prevailed during the last war, in which it was believed that the individual under survival conditions must eat only carbohydrates in order to preserve water. With the development of newer information we now know that if the individual under such conditions has 1800 calories per day he may eat carbohydrates, fat, and protein, provided they are in proper balance, and still preserve water equally well or even better than is the case if he eats carbohydrates only. That finding suggested the possibility of developing survival rations which would not only have the right composition with respect to carbohydrates, fat, and protein, but which would also have the right texture and acceptable flavor. In other words, the possibility was opened up for developing rations with higher acceptability than those used during the war, which consisted only of carbohydrates. The present problem is concerned with the development of such items, and if that development is successful we will enlist for the benefit of the survivor not only additional physiological factors but also psychological factors, which were pointed out as being almost as important as those of a physiological nature.

The Quartermaster Food and Container Institute was charged with the task of putting this information to practical use in the development of such rations. A description of the desired rations or ration items was contained in the directive dealing with the initiation of the new project. Although much of this information has been mentioned this morning, I would like to read a portion of this directive to indicate the objectives set up when this development was begun. We shall then see how much we have accomplished thus far and how much remains to be done.

The following is the statement of requirements which has been submitted by the Aero Medical Laboratory (15 January 1947):

1. Nutritional requirements of the ration (a ration is the supply of food for 1 man for 1 day.)
   a. Total daily caloric intake - 1800 calories per man per day
   b. Proportions of nutrients -
      Protein: 35-40 gms. per day (8-10% of calories)
      Fat: 40-60 gms. per day (20-30% of calories)
      Carbohydrates: 275-325 gms. per day (60-70% of calories)
      Vitamins and minerals: As provided in the natural food composition of the ration.
   c. Food composition - Protein sources of highest nutritional value (e.g., largely from dehydrated whole egg or egg white, rice flour, dehydrated skimmed milk); fat sources to be non-rancid and subject to a minimum of deterioration (egg yolk, shortening); and carbohydrates chiefly from dextrins, soluble starches (rice flour) and sucrose.
   d. Highest order of acceptability - The ration to be palatable, edible under extremes of temperature (-50° to +120° F.), non-thirst provoking (subjectively), swallowed easily with restricted free water supply (approximately 800 cc. per man per day), and varied in form, color, flavor and consistency. (The latter may be achieved in part by providing the daily ration in the form of three items, such as a sandwich-cookie, a nougat bar, and a cheese biscuit. Flavors should be mild and not too sweet.)

2. Military and technical requirements:
   a. Maximum caloric content with minimum weight and cubage (bulk or space.)
      (1) Caloric density: Equal to or greater than 4 calories per gm.
      (2) Total weight of ration: Equal to or less than 450 gms. per ration.
      (3) Total cubage of ration: Equal to or less than 30 cubic inches per ration.
   b. Stability and durability:
      (1) Eighteen months' storage without impairing acceptability and nutritive value. [It must withstand: 6 months at 100° F. Short periods at 120° F. (up to 2 weeks). Repeated freezing and thawing (-65° F.).]

Those are the requirements to be met by the ration we are attempting to develop. As you will notice, they are quite rigid, and for that reason a ration meeting all those requirements will not be developed overnight. I should mention here that a ration was developed earlier which was ideal from the standpoint of composition in that it contained carbohydrates, fat, and protein in the proper proportions. It did leave much to be desired from the standpoint of acceptability. In our recent attack on the problem at the Institute we presented the problem to each of the branches of the Product Development Division and suggested that they develop as many bars with as much variety as possible, in order that we might have a large number of bars from which we could later choose the ones most suitable. The result of those investigations was that 18 bars were developed; these were examined in the laboratory for acceptability and composition. In general, bars varied widely in composition from a strictly cereal type to the confection type.

The first group of bars (Table I) which we termed the cereal bars, were developed by the Cereal and Baked Products Branch of the Institute. These bars are first baked as a cake and then slightly compressed into the form of a bar. The flavor can be varied as indicated but the general composition is the same except with respect to flavor.

The next type was the fruit cereal bar, which consisted of different amounts of cereal and fruit; namely dates and apricots, to give flavor. The cereals used were wheat and rice.

Table I

COMPOSITION OF CEREAL BARS

	%
Wheat Flour	24.38
Soya Grits	6.97
Rice Flour	3.48
Shortening	26.13
Dried Whole Eggs	8.71
Dried Egg Albumen	8.71
Sugar	20.91
Salt	.53

Flavors	
Oatmeal	1
Cocoanut	5
Vanilla	4
Chocolate Malted Milk	3
Cheese	2

Table II

COMPOSITION OF FRUIT-CEREAL SURVIVAL RATION BARS

Bar Number	6	7	8	9	10
Ingredients	%	%	%	%	%
Dates	10	10	40	30	30
Apricots, Evap'd.	50	50	20	30	30
Wheat-Puffed	5	--	5	5	15
Rice-Puffed	10	15	10	10	--
Egg White-Dried	10	10	10	10	10
Fat-Hydrogenated	15	15	15	15	15

Five different bars were developed from those combinations. (Table II.) Tables III, IV, and V give the composition of other bars of various kinds which have been developed. The ingredients are quite varied and quite different from those presented in Tables I and II. Obviously the textures and flavors of the bars are equally varied.

All of the bars were made up in small quantity in the laboratory and subjected to preliminary acceptability tests utilizing 20 individuals in the Institute. The order of their acceptability is presented in Table VI. It is indicated that all the bars were within the acceptable range.

The next step in the work was an attempt to put the bars together to form the ration described in the original proposal. Dr. Berryman made calculations concerning possible rations comprising different bars. For instance, the first 12 bars furnish 46 gm. of protein, 79 gm. of fat, but only 171.9 gm. of carbohydrates. The ratio is protein 2, fat 3.4, and carbohydrates 7.4. Since the recommended ratio is 2:3:14, the lack of carbohydrates is apparent. A number of such possible combinations were calculated in the same manner. In every case the result was the same--the protein and fat ratio was fairly good but the carbohydrate was only approximately half of what it should be.

The best ration which we were able to make up from the items available is presented in Table VII. In order to increase the carbohydrate, use was made of a starch-jelly bar which was available and which consists mainly of carbohydrate. This ration as presented furnished 1949 calories and the protein-fat-carbohydrate ratio is 2:2.8:10.2. The carbo-

Table III

COMPOSITION OF MODIFIED "SWEETMEAT" BAR

	%
Sugar	33.7
Vinegar	4.4
Milk Fat	3.7
Cocoanut Oil	1.9
Hydrogenated Cottonseed Oil	1.9
Whey (Dried)	3.7
Cheese (Processed American)	3.7
Skim Milk Solids	5.5
Peanut Butter	18.4
Egg White (Dried)	9.2
Water	14.5

Table IV

COMPOSITION OF MISCELLANEOUS SURVIVAL RATION BARS

Bar Number	1*	2**	3***
Ingredients			
	%	%	%
Egg White	6.8	7.5	7.5
Peanut Butter	31.8	35.0	
Strawberry Jam	31.8		
Dextrin	18.1	10.0	10.0
Soda Crackers	11.3	47.5	47.5
Cheese			25.0
Whey (Dried)			10.0

* Peanut Butter-Strawberry Bar
** Peanut Butter-Cracker Bar
*** Cheese-Cracker Bar

Table V

COMPOSITICN OF CONFECTION-TYPE BARS

Bar Number	1	2	3*
Ingredients			
	%	%	%
Egg Albumen	4.5	8.7	10
Hershey Tropic Bars	90.0		
Cocoa Butter	4.5		
Chocolate Liquor (Dried)		60.2	
Powdered Sugar		30.1	
Fat			30
Sugar			60

* Vanilla Flavor, Raisins (10 gm.) or Dates (15 gm.)

Table VI

ORDER OF ACCEPTABILITY AND COMPOSITION OF SURVIVAL BARS

TYPE OF BAR	Cal. per oz.	Prot. g/oz	Fat g/oz	Carb. g/oz	Comp. Rank
Peanut Butter & Strawb. Jam	130	4.2	4.7	17.6	5
Modified Sweetmeat	121	4.9	5.4	13.3	6
Oatmeal Cereal Bar	145	4.9	8.5	12.1	6
High Date, Low Apricot, Wheat & Rice	113	3.1	4.4	15.3	8
Chocolate Liquor Base Confection	117	3.7	5.6	13.0	12
Cocoanut Cereal	146	4.9	8.7	12.1	13
Vanilla Cereal	145	4.9	8.5	12.2	13
Medium Date, Medium Apricot, Wheat & Rice	113	3.2	4.4	15.1	13
Chocolate Malted Milk	148	4.2	8.9	12.7	18
Medium Date, Medium Apricot & Wheat	113	3.4	4.4	15.0	19
Tropical Chocolate	149	3.1	8.3	15.5	20
Date & Vanilla	148	2.1	7.5	18.0	20
Cheese Cereal	130	6.0	9.4	11.4	21
Low Date, High Apricot, Wheat & Rice	112	3.4	4.3	14.8	23
Cheese & Cracker	130	6.0	5.1	15.1	25
Peanut Butter & Cracker	138	5.5	6.3	14.8	26
Raisin & Vanilla	147	2.2	7.7	17.2	26
Low Date, High Apricot & Rice	112	3.4	4.4	14.8	29

hydrate is still low but less than without the starch-jelly bar. You have samples of this ration which have been assembled for your observation and examination.

That is the state of development at the present time, and as you can see, there is still much to do. In a preliminary way the bars seem to be fairly acceptable. However, the composition is not what it should be; mainly, there is too little carbohydrate. There are other things which remain to be investigated; for instance, we do not know their keeping properties. So far we have not had the opportunity to carry out the necessary storage studies. For these reasons we should prefer to have you consider the data as merely preliminary. The development is far from final, and we hope that no one came to this meeting expecting to hear us say that we had developed a ration, and that the job is finished. Actually, we have made a beginning but further work is necessary to bring us to the desired goal.

DR. LIGHTBODY:

We can now have a report of the food acceptance test conducted on the 14 bars presented to the conference this morning. This report will be presented by Mr. J. E. P. Libby of the Food Acceptance Branch. Mr. Libby.

MR. LIBBY:

From the judgments recorded this morning the following data were extracted for each bar:

(1) The Group Average Rating on one to ten scale
(2) The Group Average Rank
(3) The Percent of Group rating the bar "Acceptable".

The 14 items were then ranked from one to 14, going from best to worst, on each of the above evaluations. This operation serves to make the 3 evaluations directly comparable; the

Table VII

SURVIVAL RATION (TENTATIVE)

	Weight oz.	Weight gm.	Cal.	Prot. g.	Fat g.	CHO g.
Oatmeal Cereal Bars (4)	4	113	578	19.6	34.0	48.4
Sweetmeat Bars (2)	2	57	243	9.8	10.8	26.6
Peanut Jam Bars (2)	2	57	259	8.4	9.4	35.2
Date Apricot Bars (2)	2	57	222	6.2	8.3	30.6
Chocolate Malt Bars (2)	2	57	234	7.4	11.2	26.0
Starch Jelly Bars (2)	2	57	203	.1	.2	50.7
Hard Candy Squares (4)	0.6	17	66			16.5
Coffee Packages (2)	0.4	10	36	1.0		8.0
Orange or Grape Beverage Packages	0.2	7	28			7.0
Sugar Cubes (4)	.8	20	80			20.0
TOTAL	16.0	452	1949	52.5*	73.9	269.0
RATIO				2	2.8	10.2

* 58.8 percent of protein from egg sources.

three ranks so obtained for each bar were now summed. In these final scores, the lowest score is the best over-all evaluation--the highest sum is the worst.

The data so obtained are shown in Table I. Corresponding data for an earlier test at the Institute are shown in Table II.

The seven best were Oatmeal, Coconut, and Chocolate bars from the Cereal group; High Date and Medium Date with Rice from the Fruit group, plus Modified Sweatmeat and Peanut Butter and Jam from the Dairy group. The poorest two were the Cracker bars.

The best seven, worst two, and intermediate five form well-defined classes--with significant differences in acceptability. In results of the Institute test the same seven items formed a distinct top class; the same five the intermediate class, and the same two the poorest class. The order in which the items appeared within a class varied slightly from Institute to conference but such variation was not statistically significant.

Conference judges exhibited maximal possible variations. One judge classed five items as "Excellent, not thirst provoking, would wear well over a period of days"; another classed the same items as "Repulsive, very thirst provoking." Average of such variations (standard errors of means) in the conference group were two to four times corresponding figures from the Institute. Average evaluations and variations showed no significant differences between the military and the civilian personnel of the conference.

The significantly smaller variation in Institute results permits dependable evaluation with smaller groups--on the order of a third of the conference group to achieve the same result. This phenomenon is chiefly attributable to the superior test environment of the Institute and to the experience of Institute judges. That experience does not make the judges a typical of the population is seen in the duplication of average ratings given by trained and untrained judges; rather, experience reduces variation through stabilization of the judges' subjective criteria.

DR. LIGHTBODY:

The next paper will be presented by Capt. James A. Roth of the Aero-Medical Laboratory, Wright Field, Ohio. Capt. Roth.

Table I

RESULTS OF CONFERENCE TASTE TESTS ON ACCEPTABILITY OF SURVIVAL RATION BARS

5 September 1947

Cereals	Mean Acceptability Rating	Rank	Mean Preference Rank	Rank	Percent Acceptable	Rank	Composite Rank
Oatmeal	7.4	4.0	2.6	4.0	86	3.0	11.0
Coconut	7.3	6.0	3.0	8.0	84	5.0	19.0
Vanilla	7.2	8.0	3.2	10.0	85	4.0	22.0
Chocolate malted milk	7.5	2.5	2.5	3.0	91	2.0	7.5
Cheese	6.7	10.0	3.6	12.5	77	10.0	32.5
Fruit							
High Date, Low Apricot, Wheat and Rice	7.3	6.0	2.7	5.5	81	7.0	18.5
Med. Date, Med. Apricot, Wheat and Rice	7.3	6.0	2.7	5.5	83	6.0	17.5
Med. Date, Med. Apricot, Wheat	6.5	12.0	3.6	12.5	70	12.0	36.5
Low Date, High Apricot, Wheat and Rice	6.6	11.0	3.1	9.0	76	11.0	31.0
Low Date, High Apricot, Rice	7.0	9.0	2.9	7.0	78	9.0	25.0
Dairy							
Modified "Sweetmeat"	3.4	1.0	1.6	1.0	97	1.0	3.0
Cheese and Cracker	5.6	14.0	4.0	14.0	57	14.0	42.0
Peanut Butter and Cracker	6.4	13.0	3.5	11.0	65	13.0	37.0
Peanut Butter and Strawberry Jam	7.5	2.5	2.4	2.0	79	8.0	12.5

CAPT. ROTH:

The Results of Recent Studies on the Air-Borne Life Raft Ration

In the past several months we have undertaken a study of survival in the cold environment as can be simulated in the all-weather chamber of the Aero-Medical Laboratory at Wright Field. Our project is yet in its infancy--one might even say, it has barely been conceived. Reporting our data today is premature. You will find, as we have, that without control studies finished, the nutritional data are difficult of interpretation. Today's presentation concerns only the first in a series of experiments to be conducted and thus constitutes at best a progress report.

In order that we place proper emphasis upon the role of a ration in the total picture, I should like to point out a few of the factors upon which the chances for survival of a castaway depend. Assuming that the aircrew member bails out and that his parachute opens successfully, his chances of survival depend upon his ingenuity in meeting circumstances and upon the integration of such factors as: Protection against the environment, equipment to facilitate rescue, necessity for energy expenditure, injury or sickness, water, and lastly food (Chart I).

The inter-relationship among these factors is so closely knit that it is impossible to consider one without the others. Food provides energy for maintenance of body heat, the performance of useful work, basal metabolic processes and may be stored in the form of glycogen, fat and labile protein depots. The role of food and water in the prevention of physical

Table II

RESULTS OF INSTITUTE TESTS ON ACCEPTABILITY OF SURVIVAL RATION BARS

August, 1947

Cereals	Mean Acceptability Rating	Rank	Mean Preference Rank	Rank	Percent Acceptable	Rank	Composite Rank
Oatmeal	7.7	4.0	2.8	5.0	90	4.0	13.0
Coconut	7.4	6.5	3.0	7.0	83	7.5	21.0
Vanilla	7.3	8.5	3.3	9.5	79	12.0	30.0
Chocolate malted milk	7.4	6.5	3.0	7.0	83	7.5	21.0
Cheese	7.3	8.5	3.0	7.0	79	12.0	27.5
Fruit							
High Date, Low Apricot, Wheat and Rice	7.7	4.0	2.5	3.0	93	2.5	9.5
Med. Date, Med. Apricot, Wheat and Rice	7.7	4.0	2.6	4.0	93	2.5	10.5
Med. Date, Med. Apricot, Wheat	7.2	11.0	3.3	9.5	87	6.0	26.5
Low Date, High Apricot, Wheat and Rice	7.2	11.0	3.4	11.5	82	9.0	31.5
Low Date, High Apricot, Rice	7.2	11.0	3.4	11.5	80	10.0	32.5
Dairy							
Modified "Sweetmeat"	8.0	2.0	2.0	1.0	89	5.0	8.0
Cheese and Cracker	6.7	14.0	3.8	14.0	74	14.0	42.0
Peanut Butter and Cracker	7.0	13.0	3.7	13.0	79	12.0	38.0
Peanut Butter and Strawberry Jam	8.4	1.0	2.3	2.0	100	1.0	4.0

deterioration is well known. The physiological inter-relationship of protection against the environment, energy expenditure, water and food will be illustrated in the data to follow on nitrogen, water and energy balances.

If a plane has crashed in the Arctic, the greatest concern is protection against the environment. A carload of food would not effectively help unless the castaway has adequate shelter, clothing, sleeping bag, etc. Without them he could freeze to death before he could eat a fraction of the food. And yet, if he did not have some food, he might lack the strength and energy necessary to extricate himself from the hostile environment or to exercise hard enough to maintain a normal body temperature.

To appraise the role of a ration in the arctic survival problem, we set out to study 4 rations:

1. "Developmental" AAF Emergency Ration, No. 1; a test ration providing 1950 calories per day.
2. Starvation; serving as a negative control.
3. E-Ration; a positive control ration providing 4000 calories per day.
4. Parachute Emergency Ration; a control on current issue, providing 960 calories per day.

Environmental factors--shelter, clothing, sleeping bag, temperature, wind velocity, etc.--were to remain constant in the first phase of the study, using a number of nutritional and metabolic indices. However, urgency for provision of a ration in survival kits to be used

CHART I

SURVIVAL OF A CASTAWAY
DEPENDS UPON THE INTEGRATION OF

PROTECTION AGAINST ENVIRONMENT.

SHELTER
1. TENT
2. LIFE RAFT
   CANOPY
   AIR MATTRESS
   REPAIR KIT
3. LOCAL SOURCES
   LEAN-TO
   IGLOO

CLOTHING
1. FLYING CLOTHES
2. ANTI-EXPOSURE
3. PARACHUTE
4. LIFE PRESERVER
5. SLEEPING BAG

SOURCES OF HEAT
1. STOVES
   GASOLINE
   ALCOHOL
2. HEAT TABLETS
3. WOOD

SUNBURN OINTMENT

MOSQUITO PROTECTION

EQUIPMENT TO FACILITATE RESCUE

SIGNALLING DEVICES
1. FLARES
2. MIRRORS
3. ELECTRONIC
4. "GIBSON GIRL"

PROPULSION ACCESSORIES
1. PADDLES,SAIL
2. SPECIAL FOOT GEAR
   CRAMPONS

NECESSITY FOR ENERGY EXPENDITURE

MAINTENANCE OF BODY HEAT

DEFENSE OR SELF-PROTECTION
1. SWIMMING
2. PADDLING
3. WALKING OUT

MAKING CAMP
1. COOKING
2. SHELTER
3. SIGNALLING
4. CHOPPING WOOD

INJURY OR SICKNESS

EXPOSURE
1. MOTION SICKNESS
2. FROST BITE
3. IMMERSION FOOT
4. SALT WATER DERMATITIS
5. SUNBURN
6. SNOW BLINDNESS

PHYSICAL DETERIORATION
1. DEHYDRATION
2. STARVATION
3. KETOSIS
4. ELECTROLYTE IMBALANCE
5. NITROGEN RETENTION

TRAUMATIC INJURIES
1. FRACTURES, BURNS
2. HEMORRHAGE, SHOCK
3. INFECTION
4. INSECTS, SHARKS

DETERIORATION IN MORALE

WATER

EXPENDABLE SOURCES
1. DESALTING KITS
2. CANNED WATER

NON-EXPENDABLE SOURCES
1. SOLAR STILLS
2. RAIN PAULIN

LOCAL SOURCES
1. LAKES
2. STREAMS
3. ICE AND SNOW

FOOD

SURVIVAL RATION

LOCAL SOURCES

in the arctic theatre within the next 2 months forced our hand to turn immediately to the AAF Emergency Ration before doing the desired control studies.

We had hoped to study a minimum of 10 subjects on each ration, but because of the accelerated request for a tentative solution and the fact that we had available only one full-time technician--our study was limited to two subjects and the number of tests performed was greatly reduced.

Experimental Procedures

The plan of study was divided into 3 periods: A standardization or control phase, experimental phase and a recovery phase (Chart II). The control phase was a period of two weeks during which time "learning" was accomplished in the psychomotor performance and mental tests and a program of physical training was initiated. The latter consisted of daily work periods on the treadmill, rope skipping and striking the punching bag. The physical training was deemed necessary because of the limitation in type of activity to be permitted by eventual confinement in the cold chamber. During the second week of the control phase, the subjects subsisted on a standard regimen consisting of E-Ration, 3000 calories per day, and a constant adequate fluid intake of 2500 cc. per day. The subjects were about their usual duties and kept accurate time-activity data from which metabolic cost could be estimated. The base-line studies conducted during this control phase included: Mosenthal concentration and dilution kidney function tests; galactose tolerance and bromsulphalein retention liver function tests; daily 24-hour collections of urine for determinations of total nitrogen, total solutes, (freezing point depression) and routine urinalysis (sp.gr., pH, microscopic, albumen, acetone and sugar); fasting blood specimens every other day for non-protein nitrogen, sugar, hematocrit, sedimentation rate, red blood count, white blood count and differential; basal metabolism, electrocardiogram, chest x-ray, complete physical examination, body weight measured within an accuracy of one gram and psychomotor performance as reflected in finger dexterity, simple reaction time, code substitution and additional mental tests.

During the experimental phase, the subjects suddenly entered a cold chamber (floor space 13.5 x 19 feet) in which were simulated the circumstances of survival following a crash landing in the Arctic. The temperature in the chamber was -20° F. ±5° F. and the wind velocity 3 to 5 m.p.h. The subjects subsisted on a "Developmental" AAF Emergency Ration providing 1948 calories per day and a daily free fluid intake of 800 cc. The ration was eaten in 8 approximately equal portions; 7 of them at 2-hour intervals spaced throughout the day and the last portion was eaten as a snack during the night while in the sleeping bag. This feeding pattern was used to take advantage of the information gained from the study of Mitchell et al. (1); that is, body temperature was found to be more easily maintained in the cold environment when the subjects ate small frequent meals in contrast to the conventional three. They entered the chamber in the morning and made their exit in the morning of the tenth day, completing a period of continuous exposure to the prescribed environment for 9 days. While the men were in the chamber, the following observations were made upon them: Body temperature measured with a rectal thermometer before getting out of the sleeping bag in the morning and again 30 minutes after getting into the bag to sleep in the evening (usually at 8:00 A.M. and 10:30 P.M.); skin temperatures as registered with resistance thermometers taped to 6 representative areas of the body (palm, forearm, foot, calf, abdomen and back) were recorded 4 times daily (usually at 8:30 A.M., 11:00 A.M., 2:30 P.M. and 9:00 P.M.); daily 24-hour collections of urine and fasting blood every other day were analyzed for the same constituents as in the control phase; Douglas bag collections of expired air were obtained during the various types of activity and analyzed with the Haldane apparatus for oxygen and carbon dioxide content; correlation of this information with an accurate record of time-activity data made possible a computation of total energy expenditure; psychomotor performance was tested daily and the men examined for evidence of frostbite, dehydration, fatigue, and deterioration in morale.

After their exit from the cold chamber, the men were weighed accurately to determine cumulative weight loss and the studies made during the control phase were again repeated. The subjects subsisted on the control regimen of E-Ration, 3000 calories per day, and a constant free fluid intake of 2500 cc. per day during the 4-day recovery period of observation.

The "Developmental" AAF Emergency Ration used in this study is illustrated in Figure 1. It consisted of 6 egg nog bars, 2 cheese-cracker bars, 2 chocolate malted milk bars, 2

CHART II

EXPERIMENTAL DESIGN

REGIMEN	2500 CC. FLUIDS 3000 CAL. E - RATION	800 CC. FLUIDS 1948 CAL. AAF EMERGENCY RATION	2500 CC. FLUIDS 3000 CAL. E-RATION
TESTS	KIDNEY FUNCTION LIVER FUNCTION TESTS URINE (24 HR; COLLECTION) TOTAL NITROGEN TOTAL SOLUTES ROUTINE URINALYSIS BLOOD (FASTING) NPN SUGAR HEMATOCRIT SEDIMENTATION RATE RBC, WBC, HGB DIFFERENTIAL BMR EKG CHEST X-RAY PHYSICAL EXAMINATION PSYCHOMOTOR PERFORMANCE BODY WEIGHT TIME - ACTIVITY DATA	BODY TEMPERATURE, 2X / DAY SKIN TEMPERATURE, 4X / DAY URINE (24 HR. COLLECTION) TOTAL NITROGEN TOTAL SOLUTES ROUTINE URINALYSIS BLOOD (FASTING) NPN SUGAR HEMATOCRIT RBC, WBC, HGB SEDIMENTATION RATE DIFFERENTIAL DOUGLAS BAG- O_2 CONSUMPTION DAILY PHYSICAL EXAMINATION PSYCHOMOTOR PERFORMANCE TIME - ACTIVITY DATA	LIVER FUNCTION TESTS URINE (24 HR. COLLECTION) TOTAL NITROGEN TOTAL SOLUTES ROUTINE URINALYSIS BLOOD (FASTING) NPN SUGAR HEMATOCRIT SEDIMENTATION RATE RBC, WBC, HGB DIFFERENTIAL BMR EKG FOLLOW-UP PHYSICAL EXAM. PSYCHOMOTOR PERFORMANCE BODY WEIGHT TIME - ACTIVITY DATA
DAYS	1 2 3 4 5 6	7 8 9 10 11 12 13 14 15 16	17 18 19 20
	CONTROL PHASE	EXPERIMENTAL PHASE	RECOVERY PHASE

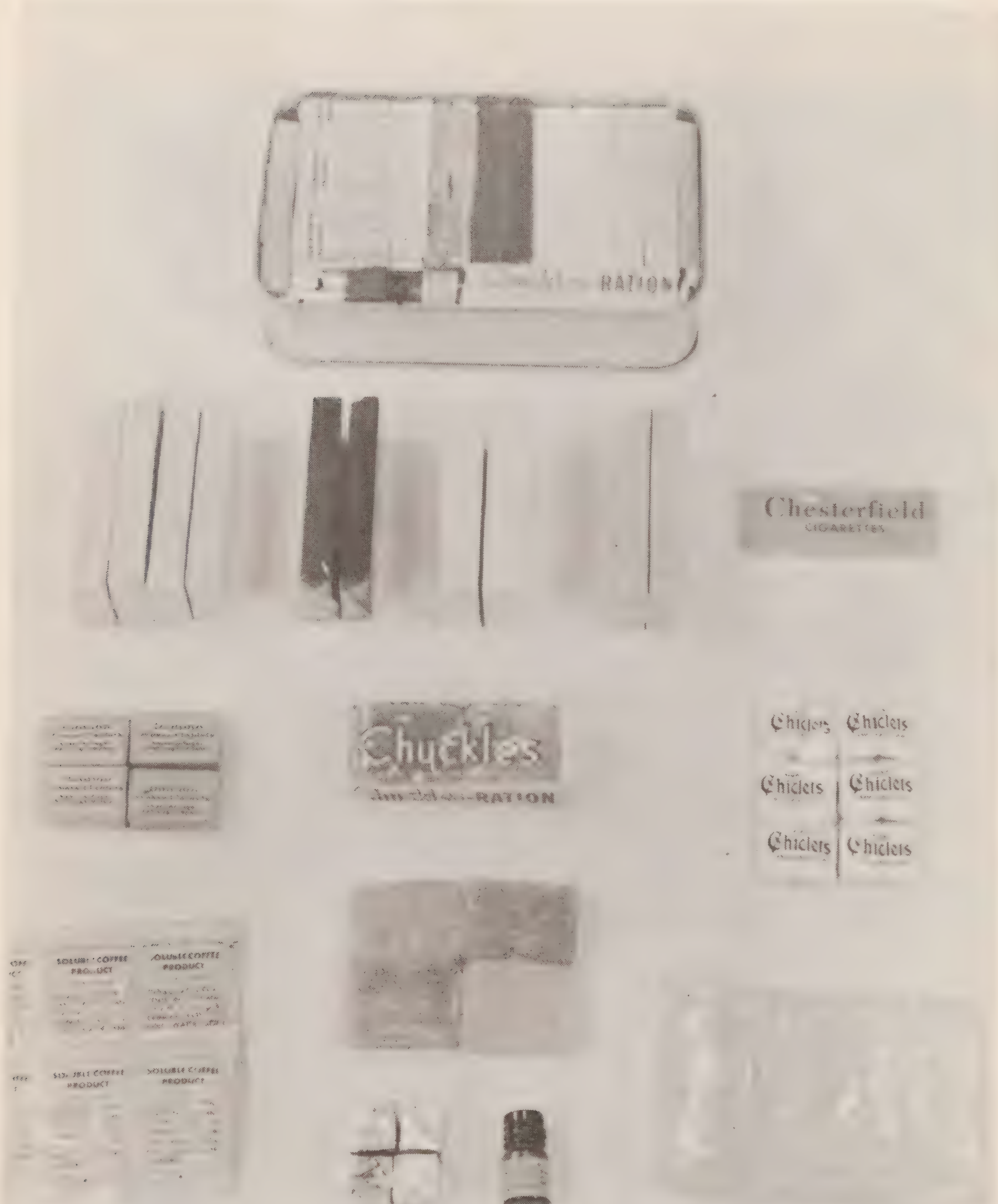

Figure 1. AAF EMERGENCY RATION "DEVELOPMENTAL"

FIGURE 2. EXPERIMENTAL AAF ARCTIC CLOTHING ASSEMBLY

FIGURE 3. HAND AND FOOT GEAR. THE SLEEPING ASSEMBLY FOR THE FEET APPEARS IN THE MIDDLE.

FIGURE 4. AIR MATTRESS, EXPERIMENTAL AAF ARCTIC SLEEPING BAG AND PONCHO-SURVIVAL TENT.

FIGURE 5. SUBJECTS WALKING ON TREADMILL.

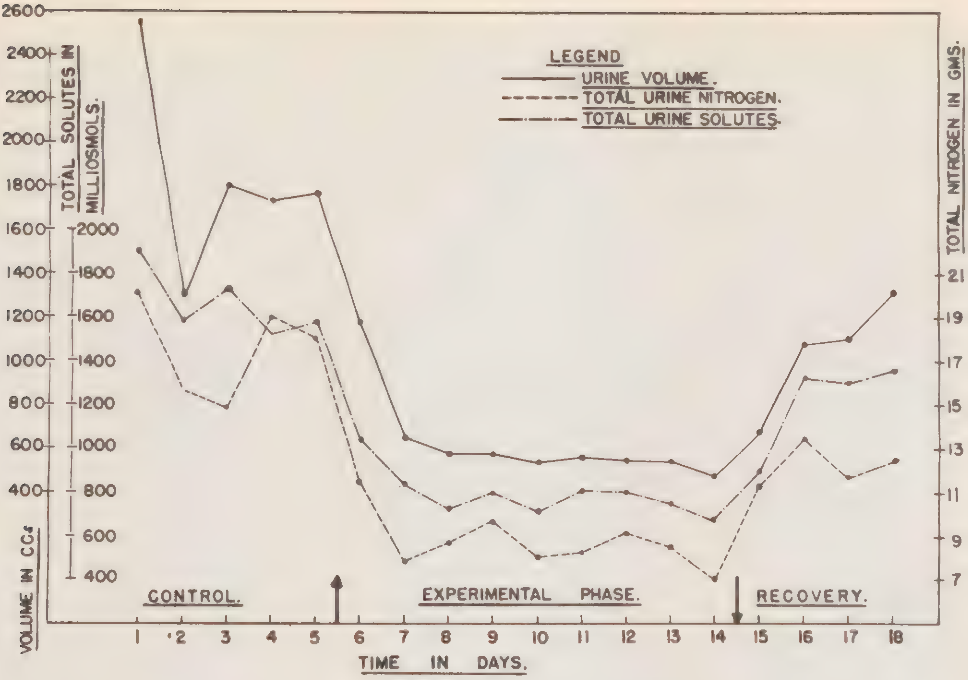

Figure 6. Course of urine volume, total urine nitrogen and total urine solutes during the 3 phases.

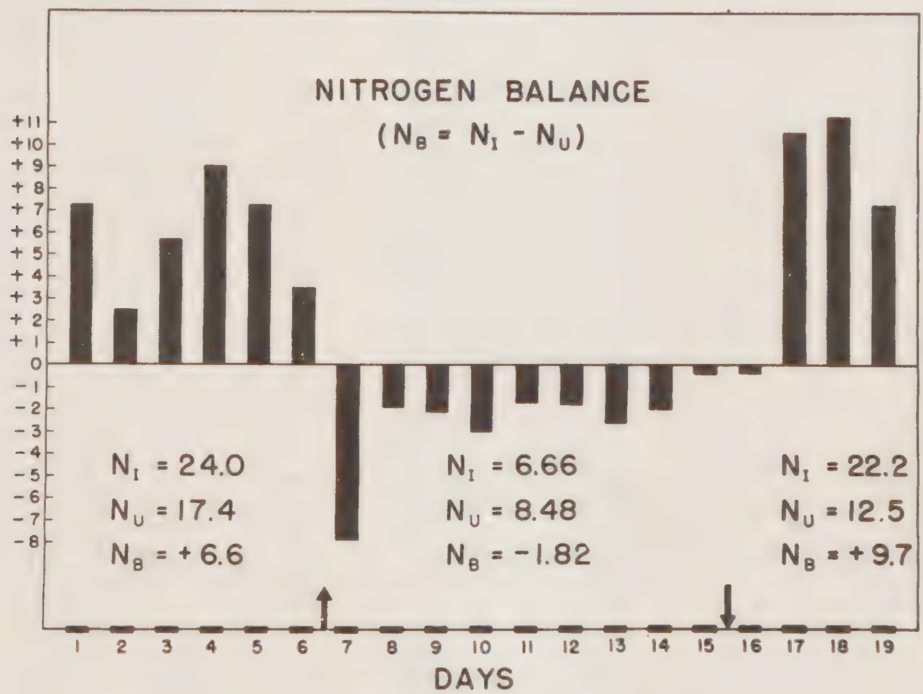

Figure 7. Nitrogen Balance. The figures are averages for nitrogen intake, urine nitrogen and nitrogen balance in grams during the last 3 days of the control and recovery phases and the last 6 days of the experimental phase.

packages of starch-jelly bars (Chuckles), 6 packages of candy-coated gum (Chiclets), 2 bouillon cubes, 2 packages of soluble coffee product, 4 cubes of sugar, 1 bottle of halazone tablets, 3 cigarettes and a cellophane bag for left-overs. This ration provided 1948 calories per man per day (Table I) of which 65.3 percent came from carbohydrate, 8.5 percent from protein and 26.2 percent from fat. The ration contents weighed 456 grams of which 76.5 percent were carbohydrate, 10.0 percent protein and 13.5 percent fat by weight. The sources of protein in this ration were mixed: 46 percent from whole egg, 23 percent cake flour, 18 percent cheese, 4 percent malted milk, 2 percent chocolate and 7 percent from extractives of meat and coffee. The rationale for the nutrient composition was based largely upon the studies of Drs. Swanson, Allison and Schwimmer which you heard summarized this morning. The ration was processed by the Quartermaster Food and Container Institute according to requirements prescribed by the Air Materiel Command (2).

The experimental Air Forces clothing assembly worn by the subjects while in the cold chamber is shown in Figure 2. It consisted of a modified cotton "sweat suit" for underwear, O.D. blanket trousers and jacket, and an outer garment of trousers and Parka jacket with double wool pile insulation covered with nylon. The insulating quality of clothing has been defined in clo units (3). One clo represents the insulation necessary to keep a resting, sitting, man comfortable under prescribed conditions of environment; i.e., when temperature is +70° F., air movement 20 feet per minute, and relative humidity less than 50 percent. The complete clothing assembly worn by the men had a clo value of 4.5 as determined on the copper man. The hand and foot gear is illustrated in Figure 3. During the daytime the men wore lightweight wool socks, a shearling inner boot, and on the outside of this an all-rubber mukluk. The outer two parts of this assembly were taken off at night and a second pair of socks (intermediate weight wool) and a wool pile sleeping boot were put on while in the sleeping bag. The hands were protected by a rayon finger glove, covered in turn by a woolen knit mit and a leather mit with fur on the dorsum of the hand.

The men slept in their clothing inside of an experimental AAF arctic sleeping bag on top of a Quartermaster air mattress (Figure 4). The sleeping bag has a clo value of 7.0 but the insulation provided by the air mattress has not yet been determined. An experimental AAF neon red poncho-survival tent covered the sleeping bag to protect it from condensation "snow."

Activities in the cold chamber were limited to sleeping (average 5 hours,41 minutes), lying in the sleeping bag (4 hours, 54 minutes), sitting (2 hours,37 minutes), eating (1 hour, 56 minutes), walking (7 hours, 9 minutes) walking on the treadmill (50 minutes)(Figure 5) and playing catch with an over-sized stuffed ball (55 minutes). Occasionally the men struck at a punching bag, and a radio-phonograph was available for their entertainment.

Results

The results of these studies have been summarized in the graphs and tables which follow and represent the data collected on one of the subjects. The data from the other subject reflected the same pattern with few minor differences.

In Figure 6 the course of 24-hour urine volumes, total urine nitrogen and total urine solutes through the 3 successive phases are presented. The urine volumes averaged 541 cc. during the last 6 days of "deprivation" in the cold chamber, the total urine nitrogen 8.48 gm. and the total urine solutes 763 milliosmols. Nitrogen balance* is portrayed in Figure 7. The average nitrogen balance during the last 6 days of the experimental phase was -1.82 gm. The delay in return to control values for the urine volume and total urine nitrogen and the more positive nitrogen balance in the recovery phase may reflect the rehydration and nitrogen repletion of convalescence. The critical nutritional data are summarized in Table II.

I would like to point out that these results are not as favorable from the standpoint of nitrogen and water balances as those obtained by Dr. Schwimmer (4). In his group of subjects exposed to room temperatures, expending approximately 2500 calories, and subsisting on a ration that provided 1800 calories per day with 15 percent fat by weight and 12.5 percent protein (6.6 gm. N), the sole source of which was egg white, the average results were as follows:

* Nitrogen balance is used here to indicate the difference in nitrogen intake and urinary nitrogen output.

TABLE I

AAF EMERGENCY RATION

COMPONENT	QUANTITY	WEIGHT gms.	CHO	PRO	FAT	CALORIES
EGG NOG BARS	6	168	103.0	22.58	32.18	793
CHEESE-CRACKER BARS	2	56	22.2	10.72	15.84	274
CHOCOLATE-MALT BARS	2	56	38.6	5.34	8.6	253
STARCH JELLY BARS (CHUCKLES)	2	112	104.0	0.0	0.0	416
BOUILLON CUBES	2	8	2.0	1.0	0.0	12
SUGAR CUBES	4	22	22.0	0.0	0.0	88
GUM (CHICLETS)	6	24	18.0	0.0	0.0	72
COFFEE PRODUCT, SOLUBLE	2	10	8.0	2.0	0.0	40
TOTAL	26	456	317.8	41.6	56.6	1948
% - WT.			76.5	10.0	13.5	
% - CAL.			65.3	8.5	26.2	

TABLE II

SUMMARY OF DATA

	CONTROL PHASE	EXPERIMENTAL PHASE	RECOVERY PHASE
DIET (GMS.)			
CHO	409 (62.0)	317.8 (76.5)	411 (64.0)
PRO	150 (22.6)	41.6 (10.0)	132 (20.2)
FAT	102 (15.4)	56.6 (13.5)	102 (15.8)
AVE. CALORIC INTAKE	3157	1948	3106
AVE. CALORIC OUTPUT	2990	3180	2610
BODY WEIGHT, POUNDS	150.8	143.9	149.4
N-INTAKE, GMS.	24.0	6.66	22.2
AVE. TOTAL URINE - N, GMS.	17.4	8.48	12.5
AVE. N-BALANCE, GMS.	+6.6	-1.82	+9.7
AVE. TOTAL URINE SOLUTES, MOsm	1614	763	1435
AVE. URINE VOLUME, CC.	1765	541	1158
AVE. % LYMPHOCYTES	41	54	36
BMR	-7		-9

Ave. Total Urine Nitrogen	= 6.15 gm.
Ave. Nitrogen Balance	= + 0.42 gm.
Ave. Total Urine Solutes	= 356 MOsms.
Ave. Urine Volume	= 347 cc.

Under the conditions of his experiments, his ration was less dehydrating and imposed less solute and nitrogen load upon the kidneys. The more favorable results obtained by Dr. Schwimmer may be explained in part by the differences in sources of protein used in the rations as indicated in the studies reported this morning by Drs. Swanson and Allison. However, there were other differences in experimental design which warrant consideration; namely, feeding pattern, environmental temperatures, activity and other minor differences in dietary composition.

Total energy expenditure was computed from oxygen consumption and time-activity data and found to average 3180 calories per day during the cold chamber run. This can be checked by a consideration of the various factors in energy expenditure (Table III).

Total energy expended is equal to that lost through the performance of useful work plus heat loss, heat lost through the clothing and sleeping bag, heat lost by warming inspired

TABLE III

ENERGY EXCHANGE

TOTAL ENERGY EXPENDED = $W + H_{cl} + A + E_1 + E_s$ =	3566 CALORIES
W = USEFUL WORK = 10% OF TOTAL ENERGY (3180) =	318
H_{cl} = HEAT LOSS THROUGH CLOTHING AND SLEEPING BAG =	2200
$A + E_1$ = HEAT LOSS THROUGH WARMING INSPIRED AIR AND EVAPORATING MOISTURE FROM LUNGS =	704
E_s = HEAT LOSS FROM EVAPORATING INSENSIBLE PERSPIRATION FROM THE SKIN =	344
	3566
TOTAL ENERGY EXPENDITURE ESTIMATED FROM OXYGEN CONSUMPTION AND TIME - ACTIVITY DATA =	3180
MEAN TOTAL ENERGY EXPENDITURE =	3373
EFFECTIVE CALORIC INTAKE (1950 - 10%) =	1750
DAILY CALORIC DEFICIT =	1623
EQUIVALENT CUMULATIVE WEIGHT LOSS (9 DAYS) =	5.3 POUNDS

TABLE IV

WATER BALANCE
(9-DAY PERIOD)

GAIN		LOSS	
FREE FLUID INTAKE	7200	URINE	4655
W_{ox} EXOGENOUS	2340	INSENSIBLE WATER	7200
W_{ox} ENDOGENOUS	1880	FECES	450
DIET WATER	405		
	11,825		12,305 cc.

NET WATER BALANCE = -480 cc.

air and evaporating moisture from the lungs and skin, and heat debt due to cooling body tissues. Body temperatures never fell below 98° F. and skin temperatures remained within the range for comfort. It is, therefore, assumed for the purpose of these calculations that the heat debt was negligible. If one were to assume a work efficiency of 10 percent, the number of calories lost in this way would be 318 on the basis of a total caloric expenditure of 3180 calories. Actually, the work efficiency for the 24-hour period might be more nearly 3 percent, equivalent to 95 calories. Heat loss through clothing is estimated from the equation:

$$H_cl = \frac{3.09\ (Ts - To)}{I_c l + I_A} = \text{calories}\ /M^2/hr$$

Ts = weighted skin temperatures = + 87° F.

To = operative environmental temperature = -20° F.

$I_c l$ = clo value of clothing = 4.5

I_A = insulating value of air under conditions of the chamber = 0.3

From the number of hours spent in the sleeping bag and that out of the bag, and from the clo values of the clothing assembly and sleeping bag, heat loss through this avenue was estimated to average 2200 calories per day. Heat loss via the lungs (warming air and vaporizing water) was estimated from the line chart in the NRC Report (CAM No. 390, Clothing Test Methods) to be 704 calories for air inspired at -20° F. On the basis that approximately 50 percent of the insensible water loss occurs through the skin and that 24 percent of the total heat loss occurs through evaporation of insensible water from both skin and lungs, it was estimated that 344 calories were dissipated in this manner. The total energy expenditure estimated by consideration of these various routes of heat loss was 3566 calories which checks reasonably well with the 3180 calories computed from oxygen consumption data. If we assume 10 percent loss through lack of digestion and absorption, the effective caloric intake would be 1750 calories and the daily caloric deficit 1623 calories. This would be equivalent to a cumulative weight loss of 5.3 pounds over the 9 days exposed to the cold environment (calculated from the total urinary N, oxygen consumption, CO_2 production, pulmonary ventilation, total RQ and non-protein RQ).

Water balance for the 9-day period is summarized in Table IV and indicates a net loss of 480 cc. equivalent to a weight loss of approximately one pound. The combined calculated weight loss due to water and endogenous catabolism is 6.3 pounds compared to the observed weight loss of 6.9 pounds.

The blood non-protein nitrogen, sedimentation rate, hematocrit, white blood count and red blood count were consistently within normal range throughout the study and showed no directional trend or change. A relative lymphocytosis was observed in the subject with 71 percent lymphocytes present on the second day in the cold chamber, 63 percent on the fourth day, and averaging 54 percent over the 9-day experimental phase. Failure to demonstrate hemoconcentration or leukocytosis, which have been reported to occur as a result of cold stress, is understandable since our subjects were adequately clothed.

Conclusion

In conclusion it may be said that the maintenance of normal body and comfortable skin temperatures without the necessity for exhausting exercise and an average loss of only 6.1 pounds in body weight over the 10-day period speaks very favorably of the combined benefits of the clothing assembly, sleeping bag and ration. How much of the total picture can be attributed to the ration cannot be said until the control starvation studies are completed. The nitrogen and water balances are not as favorable as desired and may, in part, be explained by the mixed sources of protein used in the ration.

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(2) Roth, J.; Survival Ration - Nutritional Requirements and Physiological Aspects; Air Ma-

teriel Command Memorandum Report TSEAA- 691-3D, dated 18 February 1947.

(3) Gagge, A. P., Burton, A. C., and Bazett, H. C.; A Practical System of Units for the Description of the Heat Exchange of Man With His Environment; Science, 94:428, 1941.

(4) Schwimmer, D.; Protein Metabolism Studies on Reduced Caloric and Water Intake; Project Report No. 4, Committee on Food Research, Quartermaster Food and Container Institute, dated 1 June 1947.

DR. LIGHTBODY:

The last paper on this afternoon's program will be presented by Dr. R. E. Johnson, Director of the Medical Nutrition Laboratory, Chicago, Illinois. Dr. Johnson.

DR. JOHNSON:

General and Clinical Aspects of the Assessment of Nutritional and Metabolic Condition in the Field

In a series of surveys of groups of soldiers living and working in a variety of climates, some of them extremely rigorous, I have been impressed with the manifold and complex possible causes of physical deterioration, which include emotional disturbances in uncomfortable or perilous surrounding, diseases that are not fully incapacitating, the rigors of work, environmental extremes, inadequate or improperly used equipment and combinations of many types of nutritional deficiency. Unless these complexities are emphasized constantly, serious errors of interpretation may arise in nutritional surveys. The present paper deals with my experiences with young men active in the field, and the results and conclusions are not necessarily applicable without reservation to other age groups or other types of population.

The assessment of nutritional status in the field should employ as many various technics as are practical under sometimes difficult and primitive conditions. Too much reliance on any one technic may lead to grossly erroneous conclusions. In our experience a man is adequately nourished if he maintains good physical fitness and morale in the day's work, if he remains free of clinical symptoms or signs of deficiency and if he avoids chemical desaturation of any of the important nutrients. I have employed in the field a system of diagnosis depending on consideration of : (a) detailed medical history, (b) detailed dietary history, (c) routine medical examination, (d) chemical examination of blood and of urine obtained from the subjects before breakfast, (e) analysis of chemical changes resulting from a standard oral dose of ascorbic acid, thiamine hydrochloride, riboflavin and nicotinamide and (f) performance of both short and prolonged tests of physical fitness for hard muscular work.

Certain practical considerations have to be met in field surveys: (a) Men should be withdrawn from their training schedule for as short a time as possible, (b) all observations should be completed at a single session, since there is frequently difficulty in getting the same men to return on successive days, (c) men should not be asked to forego more than one meal, (d) apparatus should be sturdy, light and portable, and methods should be as nearly as possible independent of local sources of power, which are not always available or dependable, (e) finally, since observations must be made in widely different climates, special precautions for stabilizing and preserving samples must be taken.

Clinical Observations

I shall now discuss one by one the various technics employed in my system of diagnosis and emphasize some of the peculiarities of active young men:

1. Medical History -- This is elicited according to standard medical procedures system by system. In addition, careful inquiry is made into the effects of heat, wet, cold or altitude;

of inadequate equipment or clothing; of physical fatigue, and into certain fairly characteristic syndromes, such as intolerance of heat, intolerance of cold, mountain sickness, gross physical unfitness, salt cramps and inefficiency due to water deficiency. If neuropsychiatric disturbances are present, they are usually detectable in this interview.

2. Dietary History -- It must always be borne in mind that even the best field ration is not so satisfactory as a normal diet of fresh food. Intense dislikes of certain important items will always be found among men who have lived on field rations for a considerable period, and different men dislike different things. Caloric deficiency may be common among such men. Hence, likes and dislikes, intolerances and allergies must be searched for. Loss of appetite and loss of weight are important. It is usually possible to make a qualitative estimate of the intake of important nutrients, but field rations may undergo deterioration during transportation and prolonged storage. These changes may vitiate any estimate of intake, unless analyses of the food can be undertaken. Losses may also occur in preparation.

3. Medical Examination -- Particular attention is paid to the systems which reveal nutritional deficiencies on simple inspection. Among these the more important are the skin, eyes, nose, lips, gums, teeth, tongue and nervous system. The neurologic examination may well be restricted to eliciting tendon jerks and to testing the senses of light touch, pain and vibration. The abdomen, heart and lungs need not be examined routinely unless the history warrants it.

In examining troops under desert, temperate and subarctic conditions I have found certain physical signs to be extremely common and not necessarily related directly to diet. Almost all the changes discussed are commonly recognized as indicative of certain types of dietary deficiency. The commonest are: (a) carious teeth--dental care is commonly poor in many cases because of difficult field conditions; (b) gingivitis--this is commonly seen among men with poor oral hygiene and consists typically of edema of the interdental papillae, redness of the gum margins, bogginess and easy bleeding on pressure. Laceration of the gums is not uncommon from eating hard biscuits; (c) coated tongue--this is typically a thick fuzzy coating, mainly in the midline of color ranging from yellow to dark brown; (d) dermatitis--the three commonest forms are miliaria, tending to occur on the abdomen, forearms or upper legs, "leggings" dermatitis, which is a scaling dry dermatitis of the lower legs in the leggins area, and folliculitis, especially over the thighs and buttocks; (e) conjunctivitis--this is usually of the dry type with scleral inflammation in the nasal and temporal quadrants (when severe right up to the cornea) and appears to be a common effect of undue exposure to light, wind, dust and snow; (f) neurologic changes--alterations in tendon jerks are of common occurrence among the hard working infantry, and we have seen loss of knee jerks during the course of 150 miles (240 kilometers) of cross country marching. Asymmetry of vibratory sense in the legs is likewise of common occurrence among infantrymen.

4. Chemical Examination of Blood and Urine-- While the subjects are fasting before breakfast, venous blood is drawn and serum is prepared by standard methods. A timed specimen of urine is collected at the same time. The urine is stored in brown bottles and is acidified with dry oxalic acid, which stabilizes vitamin C as well as or better than does metaphosphoric acid (1). In addition, maximal stability of the vitamins of the B complex is attained at this degree of acidity. As a routine, qualitative tests are performed for urinary albumen, sugar and acetone bodies; quantitative measurements are made of whole blood hemoglobin, serum protein, serum chloride and urinary chloride, ascorbic acid, thiamine, riboflavin and factor F_2*. If indicated, a wide variety of other measurements, such as dextrose, nonprotein nitrogen and gas contents of the blood, can be carried out. I have developed a self-contained field nutritional laboratory for carrying out a wide variety of estimations under field conditions. A full description of it is being published separately.

5. Physical Fitness and Morale -- These are best tested by actual performance of the daily duties in the field. Line officers and noncommissioned officers are good judges of the condition of their men, provided a whole company has not deteriorated all together. Long forced marches give valuable information. Under most conditions information from these two sources is not always available; hence it is advisable to have some other means of testing

* Factor F_2 is sometimes designated as N^1-methylnicotinamide, although the more accurate name is N-methylpyridinium-2-carboxylic acid amide (a quaternary ammonium compound).

the men's capacity for hard work. I customarily use for this purpose a field modification of the laboratory test of Johnson, Brouha and Darling (2). This is a test of capacity for hard physical work, cardiovascular fitness and will power, and it has been of great use in dietary studies; e.g., protein studies by Darling and co-workers (3).

6. Tolerance Tests -- The merits of various types of loading tests have been discussed by Youmans and Patton (4). For practical field use the advantages of administering test doses by mouth in our experience outweigh the disadvantages. The chief arguments against oral administration are that the effects of individual idiosyncrasies of intestinal absorption appear and that the time of collecting specimens of urine is longer than when doses are injected. The chief arguments for administration of test doses by mouth are: first, that vitamin deficiencies caused by improper absorption are important and cannot be detected by injecting the test dose; and, second, that under field conditions it is often difficult to maintain facilities for sterilizing apparatus and solutions, whereas transportation of nonsterile tablets is convenient and saves space. For these reasons I have adopted the oral tolerance test employing 500 mg. of ascorbic acid, 5 mg. of thiamine hydrochloride, 5 mg. of riboflavin and 50 mg. of nicotinamide followed by collection of urine for 4 hours. This time is chosen for purely practical reasons, since it is highly desirable to dismiss the subjects in time for lunch. A longer period of collection would be better, but in actual practice the results justify these sorts of tolerance test. In experimental deficiency of vitamin C we have demonstrated the reliability of the short oral tolerance test (5).

Establishment of Diagnosis

1. Interpretation of Chemical Results -- It must be borne in mind that moderate chemical unsaturation is often found in men with unimpaired mental and physical vigor, without other evidences of nutritional disturbance and eating an apparently normal diet. Extended experience with these tests has demonstrated that individual differences in absorption and in renal threshold are rather wide. When plasma levels are measured, as in the determination of chloride and of ascorbic acid, one frequently sees in normal persons high plasma levels with low urinary levels. Therefore, only a low plasma level with a low urinary level is truly indicative of unsaturation.

In the case of substances measured only in the urine before and after loading (vitamin thiamine, riboflavin and factor F_2), one can often see both low and high fasting levels with good excretion of the test doses and also with poor excretion. "Fasting level" here refers to hourly excretion in urine passed after emptying the bladder on arising and before any food is eaten. Only a low fasting level associated with poor excretion of the test dose is considered indicative of unsaturation. These criteria are somewhat different from those of Holt (6), who has stated that a zero level of thiamine, riboflavin or factor F_2 in the fasting specimen is indicative of unsaturation with respect to thiamine, riboflavin or nicotinic acid respectively.

The accompanying tabulation is used for interpreting chemical data obtained by our field methods. It should be emphasized that the time relations in deficiency are important, but present knowledge of the relation between daily intake of nutrients and the onset of incapacity is so unsatisfactory that the criteria listed are undoubtedly open to question by some investigators.

Evidences of Chemical Inadequacy

Water	--Serum protein above 7.5 gm. per hundred cubic centimeters.
Calories	--Sometimes ketosis; sometimes hypoglycemia; nothing is pathognomonic.
Salt	--Fasting serum chloride below 98 milliequivalents per liter and fasting urine chloride less than 0.2 gm. of sodium chloride per hour.
Ascorbic acid	--Fasting serum ascorbic acid level below 0.3 mg. per hundred cubic centimeters and excretion of test dose less than 3 mg. in 4 hours.
Thiamine	--Fasting urinary excretion less than 0.6 microgram per hour, and excretion of test dose less than 20 micrograms in 4 hours.
Riboflavin	--Fasting urinary excretion less than 20 micrograms per hour and excretion of test dose less than 200 micrograms in 4 hours.
Nicotinic acid	--Fasting urinary excretion less than 0.03 mg. of factor F_2 per hour and excretion after test dose of nicotinamide less than 0.5 mg. of factor F_2 in 4 hours.

2. Necessary Conditions for Diagnosis -- I have adopted a conservative attitude in making a diagnosis of deficiency (4), (7). If the dietary history, medical history, medical examination, chemical results and tests of physical fitness all point in the same direction, some confidence can be placed in a diagnosis. In my experience, clear evidence of chemical unsaturation is a primary and indispensable requirement, and this must be supported by corroborative evidence from other sources of information. The correlation between chemical and other clinical information is often not so satisfactory as it might be. According to the "saturation theory," the highest health and efficiency are achieved only when loading tests reveal a high level of vitamins in the body. However, experiments in the laboratory and various nutritional surveys have revealed, first, that men in apparently good health can have low stores of vitamins and, second, that supplementing normal diets with vitamins does not lead to significant increases in physical fitness (8). In my own surveys, I have frequently seen severe loss of weight without undue caloric deficiency, desiccated skin without demonstrable dehydration, apparently identical neurologic changes in men with and without thiamine unsaturation, identical types of conjunctivitis and cheilosis in men with and without riboflavin unsaturation, similar reddening and atrophy of the tongue in men with low and with high urinary levels of factor F_2, and identical types of gingivitis in men with no ascorbic acid in the serum and with high levels of ascorbic acid in the serum. I have seen remarkably high physical fitness and morale in groups of men whose chemical stores were by orthodox interpretation low and extremely poor physical fitness in groups of well saturated men. I have seen adequate chemical stores in men subsisting on very unbalanced diets and low levels in men whose diet by analysis was high in water-soluble vitamins. Differential diagnosis may be extremely difficult, and there are complications in the factors of hard physical work, emotional stresses and exposure to climatic extremes. It appears that conservatism is desirable in making a diagnosis of nutritional deficiency.

Certain conditions are common to a great many nutritional deficiencies. Symptons of lethargy, inefficiency and irritability are often the first symptoms. Poor physical fitness when established by satisfactory tests means one of two things: either the man has never been fit or else he was at one time fit and has deteriorated. Physical deterioration in association with nutritional deficiencies is commonly observed. It should be borne in mind that a man originally in very good physical condition may show physical deterioration and still be by ordinary standards at least in average physical condition. The dietary history may be unreliable for a variety of reasons.

The following considerations lead to various diagnoses. As will be seen by the case histories to follow, a diagnosis of deficiency is made only when there is clear chemical evidence. We do not always demand positive physical findings, which usually become positive long after the beginning of chemical unsaturation.

Water

Dietary history--Inadequate intake, especially during periods of activity.
Medical history--Symptoms of heat exhaustion, particularly falling out of marches; syncope; easy fatigue in the heat; dizziness; headache; and unsatisfied thirst.
Physical examination--Dehydrated lips, tongue or skin; rapid pulse; body temperature may or may not be raised.
Chemistry--Unsaturation as indicated in the tabulation.
Physical fitness--May not be impaired for short bursts of activity, but is usually impaired for prolonged work.

Total Calories

Dietary history--Inadequate intake, especially of carbohydrate, in proportion to the daily work output.
Medical history--Progressive loss in weight; progressive increase in fatigue lassitude and decrease in efficiency and morale; hunger variable, being intense during the first few days but often decreased thereafter; bowel habits modified, usually with diminution of bowel movements; frequently nausea, with or without vomiting.
Physical examination--Nothing but evidence of recent loss in weight is usually found. There may be thick furring of the tongue, with foul breath. In case of severe deficiency

acetone may be evident on the breath.

Chemistry--There may be little abnormal, but there may be dehydration with high serum protein, acidosis with ketonemia and ketonuria, and hypoglycemia.

Physical fitness--Usually seriously impaired, even for moderate work.

Salt

Dietary history--Inadequate intake; dislike of salt and salty foods.

Medical history--Symptoms of heat exhaustion (as outlined under "Water"); symptoms of heat cramps (as outlined by Talbott (9); craving for salt.

Physical examination--Usually nothing abnormal; occasionally hyperactive tendon reflexes or tenderness of various muscle groups to pressure.

Chemistry--Unsaturation, as indicated in the tabulation.

Physical fitness--Usually impaired for hard work.

Ascorbic Acid

Dietary history--Inadequate intake of fruits, juices and vegetables.

Medical history--Usually nothing significant; in cases of severe deficiency, lethargy, painful muscles, bleeding gums or ecchymoses on the lower extremities.

Physical examination--Gingivitis, with red gum margins, edematous interdental papillae and easy bleeding on pressure; occasionally echymoses on the lower extremities, and rarely hyperkeratotic follicles, as observed by Crandon, Lund and Dill (10).

Chemistry--Unsaturation, as indicated in the tabulation.

Physical fitness--Impaired only late in deficiency.

Thiamine

Dietary history--Inadequate intake of meats, eggs and cereals.

Medical history--Multiple complaints, including lethargy, irritability, lack of ambition, anorexia, loss of weight; vague gastrointestinal symptons, including mild nausea, rarely vomiting and irregular bowel habits; loss of strength; vague aches and pains, usually in the legs, joints or back.

Physical examination--Usually nothing significant, but occasionally depression of tendon jerks, unequal tendon jerks, diminution of vibratory sense or diminution of sense of light touch.

Chemistry--Unsaturation as indicated in the tabulation.

Physical fitness--Impaired early in deficiency.

Riboflavin

Dietary history--Inadequate intake of milk, eggs and meats.

Medical history--Usually little except "sore eyes," photophobia or excessive lacrimation.

Physical examiation--Dry conjunctivitis, with scleral injection encroaching on the cornea; rarely circumcorneal injection; cheilosis.

Chemistry--Unsaturation as indicated in the table.

Physical fitness--Usually unimpaired.

Nicotinic Acid

Dietary history--Inadequate intake of meat.

Medical history--Sore tongue or mouth; irregular bowel habits, expecially diarrhea.

Physical examination--Typical dermatitis, atrophied papillae of the tongue, red inflamed tip.

Chemistry--As indicated in the tabulation.

Physical fitness--Usually impaired for hard work.

In field surveys it is essential to keep constantly in mind the various lengths of time necessary to cause inefficiency and deterioration in different nutritional deficiencies (11). Deprivation of water can kill a man in hot weather in a day or two if he is sweating profusely; and I have seen cases of exhaustion of dehydration at -20F. Caloric deficiency can demoralize working men in 2 or 3 days (as in case 7 which is to be described). Salt deficiency even in cold weather can lead to serious results in 3 or 4 days. Deficiency of the water-soluble vitamins can result in chemical unsaturation in from one to 2 weeks, with physical deterioration.

in the case of the B complex if conditions are right. Given a previously normal diet, Vitamin C deficiency can begin to cause trouble within 3 months. So far as is known at the present time, diets can be very low in protein, fat and the fat-soluble vitamins for several months without serious effects. Therefore, I place primary emphasis on nutrients,lack of which can cause trou-trouble in a short time. I have had no field experience with soldiers isolated for long periods or with civilian populations on poor diets for months or years. The technics, measurements and interpretation of results under such conditions would doubtless have to be somewhat different from those that we have outlined.

Case Histories of Nutritional Deficiencies in Men in the Field

This section consists of presentation of case histories illustrative of types of nutritional deficiency met in the field. Therapy will not be discussed in this paper. The diagnoses in cases 2, 3, 6, and 7 were substantiated by specific therapy. It should be pointed out at the outset that the percentage of such cases in troops on this continent is very low.

CASE 1 --DIETARY HISTORY--There had been a generally inadequate intake of all types of food, owing to constant anorexia in the desert.

MEDICAL HISTORY --The patient's general health was poor, with loss of 10 pounds (4.5 Kg.) after 2 months in the desert. He had experienced daily vague pains in the shoulder and legs without cramps, worse when marching; daily precordial pains with feeling of smothering and pains radiating to the left arm, and daily headaches, especially in morning. All symptoms were accentuated by exercise, during which the patient became progressively weaker. He never failed to finish a march, but he usually fell far behind and needed assistance.

PHYSICAL EXAMINATION--There were severe miliaria, conjunctivitis, severe gingivitis, dirty teeth (many carious), severe malocclusion, diminished vibratory sense and sense of light touch in the legs. The margins of the tongue were atrophied.

PHYSICAL FITNESS--The patient was so incoordinated that a satisfactory test was impossible, but his fitness was obviously poor.

CHEMISTRY--Tests revealed a high serum protein level, 8.7 gm. per hundred cubic centimeters. There was poor excretion of test doses of thiamine and riboflavin, but excretion of chloride and of factor F_2 was normal.

DIAGNOSES--The diagnoses were: (1) congenital physical and mental weakness; (2) water deficiency; (3) thiamine deficiency; (4) riboflavin deficiency; and (5) probable caloric deficiency.

CASE 2 --DIETARY HISTORY--There was nothing abnormal in the dietary history.

MEDICAL HISTORY--The medical history revealed only a frequently unsatisfied thirst.

PHYSICAL EXAMINATION--The conditions observed on physical examination were normal.

PHYSICAL FITNESS--The patient's phyical fitness was low average.

CHEMISTRY--The serum protein level was very high, 8.7 per hundred cubic centimeters, and the serum chloride level was also high, 109 milliequivalents per liter. All other measurements were normal.

DIAGNOSIS--The diagnosis was water deficiency.

CASE 3 --DIETARY HISTORY --The patient's appetite and general intake of food were poor because of anorexia while in the desert.

MEDICAL HISTORY--For 3 days previous to examination the patient had had diarrhea with slight fever. On 3 separate days in the preceding month he had epigastric pain

with episodes of nausea and vomiting, and during that month 6 successive canker sores and 3 successive boils.

PHYSICAL EXAMINATION--The patient had moderate gingivitis and one carious tooth.

PHYSICAL FITNESS--The subject was excused from the test because of recent illness, but he and his lieutenant reported that he had deteriorated badly.

CHEMISTRY--The ascorbic acid level of the serum was 0; the serum chloride level was low, 97 milliequivalents per liter. There was no urinary excretion of test doses of ascorbic acid and thiamine, but excretion of riboflavin was normal.

DIAGNOSES--The diagnoses were: (1) salt deficiency; (2) ascorbic acid deficiency; (3) thiamine deficiency.

CASE 4 -- DIETARY HISTORY-- The subject's appetite was poor after one month in the desert.

MEDICAL HISTORY--The medical history revealed: chronic fatigue; 15 pound (6.8 Kg.) weight loss in 3 months; recurrent diarrhea lasting 2 to 3 days every 2 weeks, with vomiting after meals about once a week; chronic productive cough; pains, especially in the back, during exercise; and frequent dizzy spells.

PHYSICAL EXAMINATION--The chest was clear on percussion, but the breath sounds were harsh, with many squeaks and groans. Many carious teeth were found. Knee jerks were sluggish, even with reinforcement, and ankle jerks could not be elicited. Vibratory sense was diminished on the right.

PHYSICAL FITNESS--The patient's physical fitness was rated as poor.

CHEMISTRY--Excretion of thiamine in the fasting specimen and excretion of of the test dose were low. The serum protein, chloride and ascorbic acid levels were normal. Urinary excretion of ascorbic acid, riboflavin, factor F_2 and chloride was normal.

DIAGNOSES--The diagnoses were: (1) thiamine deficiency; (2) chronic bronchitis; and (3) probable caloric deficiency.

CASE 5 --DIETARY HISTORY--This patient's diet in general had been good, but practically no dairy products of any kind had been available for 2 months.

MEDICAL HISTORY--During 3 months in the desert his "eyes had been weak," with considerable lacrimation and blood-shot conjunctivas.

PHYSICAL EXAMINATION--A dry conjunctivitis was observed, and the right temporal lower quadrant showed pronounced infiltration, probable corneal invasion. There was no cheilosis.

CHEMISTRY --There was a low fasting urinary riboflavin level, with small excretion of the test dose. Other hematologic and urinary measurements were normal.

DIAGNOSIS--The diagnosis was riboflavin deficiency.

CASE 6 --DIETARY HISTORY--The diet had been adequate.

MEDICAL HISTORY--There was a past history of one admission to a clearing station for heat cramps and heat exhaustion, but for the preceding month nothing abnormal had been observed.

PHYSICAL EXAMINATION--Moderately severe gingivitis, with easy bleeding, conjunctivitis and severe miliaria were revealed on physical examination.

CHEMISTRY--The serum contained no ascorbic acid and there was no excre-

tion of the test dose.

PHYSICAL FITNESS--The patient's physical fitness was rated as good.

DIAGNOSIS--The diagnosis was vitamin C deficiency.

CASE 7 (17 men)--Dietary History--These men had had an excellent diet until 3 days previously, when they went on an unacceptable combat ration. The average daily intake for these 3 days was 1,700 calories, and the work output was about 4,500 calories.

MEDICAL HISTORY--This had been an excellent, tough platoon, with no medical abnormalities. After 2 days of inadequate diet a majority were suffering from a variety of gastrointestinal complaints, especially nausea, occasional vomiting, loss of appetite and complete cessation of bowel movements. Pathologic fatigue was constantly present, and spirits were at an extremely low ebb. They were living outdoors in temperatures down to -30 F. and they felt the cold keenly, in contrast to their usual good adaptation. Abnormal thirst was not present.

PHYSICAL EXAMINATION--They were a group of listless, dehydrated men, with drawn cheeks and sunken eyeballs and with breath loaded with acetone. Systematic physical examination revealed no further abnormalities.

PHYSICAL FITNESS--Performance of the short severe test showed gross deterioration from the week previously. This deterioration had also been evidenced in the daily marches. One week previously they had all finished with ease a 46 mile (74 kilometer) forced march in 36 hours. After 2 days of poor diet, exhaustion curtailed at 10 miles (16 kilometers) a proposed 15 mile (24 kilometer) patrol.

CHEMISTRY--Chemical tests revealed severe acetonemia and acetonuria. The serum protein levels were high for subarctic subjects, averaging 7 gm. per hundred cubic centimeters, and the serum chloride levels were low, averaging 96 milliequivalents per liter. Urinary excretion of chloride was essentially nonexistent and of ascorbic acid was low. Excretion of thiamine, riboflavin and factor F_2 was normal.

DIAGNOSES--The diagnoses were: (1) acute caloric deficiency; (2) acidosis; (3) dehydration; and (4) chloride deficiency.

Comment

My interest has centered on active young men in the field. In my experience with solders on the North American continent eating United States Army rations, significant deficiency is rare. When it does appear, the most important cause is rejection of important items of food because of inherent unpalatability, special food habits, intolerances, allergies, poor teeth, sore gums or in hot climates the commonly observed anorexia. Reports from combat theaters seem to indicate that deficiencies in some places are relatively common, owing to problems of supply, infectious diseases, emotional disturbances and rejection of unpopular items. It would seem, therefore, that the most useful work by nutritional surveys would be in combat theaters, not in North America.

Summary

1. A system for assessing the nutritional status of young men active in the field has been developed. Emphasis is placed on the manifold and complex possible causes of physical deterioration, which include emotional disturbances, diseases, the rigors of work, environmental extremes, inadequate or improperly used equipment and many types of nutritional deficiency.

2. There are 6 types of observations that are feasible in the field, namely, medical history, dietary history, routine physical examination, chemical examination of the blood and urine obtained before breakfast, chemical changes resulting from test doses of vitamins and performance in tests of physical fitness.

3. There is sometimes a disturbing lack of correlation among the various types of observation.

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Proceedings of Afternoon Round Table Session Conference

on Survival and Emergency Rations

DR. LIGHTBODY:

We will now commence the final part of this afternoon's program. To guide this round table discussion I will call on Lt. Colonel Manley C. Perry, Chief of the Rations Planning Office of the Institute. Lt. Colonel Perry.

LT. COL. PERRY:

Throughout the day you have been spoken to, and now you are going to have your opportunity to speak. We are particularly interested in receiving your experienced comments. We want you to feel free to say what you have to say about the ration. Initially Dr. King is going to give us a brief summary. Let us bear in mind that this is an Air Force ration, from which there are very adequate lessons to be learned and used for the Ground Forces and the Navy.

DR. KING:

In attempting to review the high spots in the discussion today, I hope you will forgive me and understand the difficulty if I do not comment specifically on the good contributions of several of the speakers. The papers were all worthwhile, but there isn't time to discuss each one in detail.

Referring briefly to the contributions in order of presentation, you will notice Dr. Schwimmer's work there was a completely new and fundamentally important concept introduced, which I think you will see given wide recognition both in civilian and military problems. I refer specifically to the preliminary evidence pointing toward the importance of fat as contributing to better physiological efficiency when there is lower caloric intake. Raising the fat content from 10 to 20 percent gives a striking result. That certainly is a fundamental contribution. Not only is it fundamental, but it is practical in terms of Army rations and civilian feeding. The matter of acceptability, which was discussed by Dr. Dove, cannot be overstressed, nor can it be overstressed that the acceptability tests should go rapidly from the laboratory out to the field for testing, to be correlated with the work with white rats in Dr. Swanson's laboratory, with the work with dogs in Dr. Allison's laboratory at Rutgers, and the further studies with Dr. Schwimmer's group. This surely represents the kind of approach that ought to be followed much more widely in studies of Army and civilian feeding problems. The species differences are likely to become of less and less importance and be explained in quantitative terms and not in absolute species differences. The whole egg yolk results as contrasted with other proteins brings out the same fact--that you do have these differences, in species, but these should not be overemphasized, nor used to underevaluate the careful exploratory approach in the laboratory.

In view of the demands for brevity of treatment of the day's discussions and the wish to give you all a chance to participate in discussing the papers contributed, I am going to conclude with comments on the general value of the kind of program that has been discussed today. First, I think there should be an approach to Army rations which includes the best information we have, the best trained, experienced scientists in the field of nutrition and food technology, and these men should work in close collaboration with Medical officers, Army officers, Naval officers, and Avaition officers--men representing all the Armed Forces. That is just a preliminary thing. Secondly, that should be followed by a systematic procedure to try them out and test them under careful physiological conditions. Third, there should be small, experimental, carefully controlled human tests organized consistently to follow as rapidly as possible the animal experiments. Fourth, there should be field service tests involving sufficiently extensive time and numbers of men to certify those preliminary findings. Fifth, I would like to emphasize the need for a broad, comprehensive, and sane approach to the problem. That point was brought out very nicely by Dr. Shlesnyak in urging consideration of a margin of safety in planning Army rations - not attempting just to let a man squeeze through in a crisis, but attempting to maintain a liberal attitude in providing as high a level of nutrients as can reasonably be obtained. The matter of whole egg illustrates the point well. In a nitrogen balance experiment there may not be much difference, but if you go to whole egg, you immediately introduce a number of physiological factors, such as choline, fats, calcium, iron and other nutrients not even recognized. I think the broad comprehensive conclusion of good food with a liberal allowance of all the nutrients known and unknown should be uppermost in planning Army rations.

LT. COL. PERRY:

Thank you, Dr. King. I would like to call on the Air Forces first, followed by the Ground Forces, the Navy and the Coast Guard, in that order. I know quite a few members of the Air Forces have a number of comments they would like to make.

COL. BARTA:

I don't have anything in particular to add. I want to thank the Institute for the invitation to participate. The papers presented were most interesting to us. On the evaluation of this ration as it has been done here, it would be folly to try to express an opinion on it. I feel like other members here--that it can be improved in palatability and taste--the acceptability factor is most pronounced in this particular ration. I think these are all the comments I wish to make.

COL. KEENAN:

I am sorry I can't say anything except what Col. Barta has said. I am one of those who wrote that there was very little taste in some of them, and I still think they have very little taste.

COL. DITTMAN:

At our base during the war we had quite a bit of trouble keeping rations in the emergency life raft - candy, etc. I don't believe we'll have too much trouble keeping these. Some people seem to think they don't taste good, but I don't think we should like it too well after a breakfast of 4 eggs and 2 pieces of bacon.

LT. COL. CROWLEY:

I am afraid I have no comment to make now. I have been in Washington exactly one week, and am still getting my feet on the ground.

COL. KEENAN:

I would like to make one other statement to the effect that this is an emergency ration, and regardless of how it looks or tastes, it is up to the scientists to tell us what should go in it. If it's what is going to keep me alive up in the air or on the sea, that's all that I'm interested in. I think very strongly that this should be remembered.

DR. ROBINSON:

This is a very opportune time for us in the Air Forces and particularly those of us at the Aero-Medical Laboratory to express our thanks to the Quartermaster Corps for all they have done in developing this survival and emergency ration to the state it is now in. We realize we have presented a very tough assignment not only in terms of actual requirements but in terms of time. We had to include this for use in bail-out kits. We do want to express our appreciation for the cooperation that has existed between the Quartermaster laboratory and our laboratory, particularly in the way we get things done and talk things over at both the experimental and testing levels. I think this is an extremely good sign for future cooperation among the Armed Forces. I have one more comment along that line; in general, we presented a project which we felt was very important in terms of the physiological requirements of an emergency ration. We realize that the whole series of factors involved, including temperature, amount of work, protective environment, is so large that we can take only one small phase at a time. Yet in the last analysis we must take the whole thing; we still feel that to do the job properly that must be done eventually. In learning the physiological requirements, we should have a large co-operative project developed at some institution. I would still very much like to see the possibility being explored and perhaps developed by the Armed Forces jointly. It could be some type of major project at an institution where we would have sufficient subjects and sufficient personnel and the background that is needed to study the problem. This situation that we have presented here, first through the animal experiments and finally to the human subject level, certainly points toward that type of experiment, which must be done before we can know what we are talking about. That again precedes a final type of field study that must be done with a large number of men. I think that in the long run it can only be done at some institution where we do have all the facilities available.

LT. COL. WILTAMUTH:

From the Ground Forces point of view our C ration is actually our emergency ration if the Commanding Officers are handling the situation correctly. Perhaps we will need a survival ration or emergency ration. If so, we want something highly portable that a man can carry on his back for an indefinite period, using it in that last minute when an emergency arises. The size of this ration is too large for that purpose. The flat package is definitely what we want, and to repeat a comment that has been made, we would like to see it not so acceptable. If it is going to remain in the man's pack for the emergency, it can't be too acceptable. Of course, I want to reserve that comment for this ration only. In an emergency ration I do not see the need for cigarettes, matches, or halazone tablets. Of course that is up to the scientists, but I think a man could survive without cigarettes.

LT. COL. BOYD:

The ground soldier is known to be hungry practically all of the time, so he has a great

interest in any ration, whether it is called K, E, A, or survival. The main problem is where it should be carried and how. Some of the troops like to carry the ration in the pocket of the combat jacket, so the load must be looked at from that angle as well as others.

LT. COL. LEWIS:

As a member of the Research and Development Branch, Military Planning Division, OQMG, I would like to state that the meeting in general has been quite gratifying to us. I as an individual came here to learn, not to express my views. We are particularly interested in the view of the Air Forces, the Ground Forces, the Navy and other people who use the ration. I would like to say I think we have made some strides in the past year in the development of this particular ration. It seems to be on the right track. If it isn't, we would like to hear from our users.

LT. COMMANDER POWER:

As Liaison Officer with the Institute, I think probably anything that I can say has been said this afternoon. I am sorry that it was necessary for representatives of our using forces to leave early. I would like to have had them say a word because we are almost in the same position as the Quartermaster Corps. We are trying to satisfy their needs. Their needs are the ones that are important and should be expressed. Of course the survival that we are worried about in the Navy is mainly survival at sea. You probably all know that the Navy always thinks of things in terms of afloat operations. The provisions made for liquids in the survival ration are very important to us, and I think that this point has been quite well discussed here today.

LT. HERRON:

I would like to express for Commander Dietz and Admiral Buck their regrets that they were not able to attend the conference. As you have been told, we are more interested in survival at sea, and for that reason we would like to express the emphasis to some degree on the psychological effect that a ration has on a man. True, that makes it more inviting for him to pilfer a ration before having to launch the life raft, but I think that the psychological aspect does play a very important part in survival. I wanted to express that point in relation to some of the items we tasted today.

MAJOR HOLMES:

In relation to the development of an Air Force emergency ration, the Marine Corps stands in its usual symbiotic relation to the other branches. Our own Air Force would of course participate in whatever designs are developed and accepted by the Naval Air Force. However, with regard to our Ground Forces, the major portion of the Marine Corps, I would like to second the comments that the Army Ground Forces had to make. We are chiefly interested in rations such as the E and C and possibly the Arctic ration and perhaps a portable assault ration. Research of this type may tend to produce something which could be adapted for those purposes in which we are interested. The development of the flat package for this purpose is excellent and should be extended to other rations which are used for emergency purposes. In this connection, although it is an Air Force ration, I am sure that for escaping from the emergency situation, portability would be highly desirable for the Air Forces as well as for any other interested party. In this connection such a ration could be carried more easily than a single E ration because of its flat, compact nature. It is thus a definite step in the proper direction as regards packaging.

LT. COMMANDER CONELY:

My colleague in the Navy said this afternoon that he is very dependent on his liaison officer to give him the information after the Ground Forces had done all the work. We are in the same position--we depend on the Navy for everything of that nature.

COL. BARTA:

Have you experimented on the durability of the ration under various environmental conditions?

LT. COL. PERRY:

We are working on that.

MR. EMORY W. THURSTON:

I was quite struck by the gentleman who said there were certain people who believed in the dried meat idea. As children when we went on a long hike or trip, we always used jerky dusted with a little salt and pepper, then hung up in the sun to dry. We would pack it in a tight container, and that would be our food for 4 or 5 days. In that connection I was wondering if you had tried powdered meat. It is practically devoid of taste and could be included in a cracker or something of the sort. I offer you this as a possible suggestion.

LT. COL. PERRY:

Thank you, Mr. Thurston, for your comments. We always welcome new ideas.

I only wish we had more time to discuss this matter now. However, our time is up and some of you gentlemen have trains to catch. Before we close I would like to ask Col. Lawrence if he has anything to say.

COL. LAWRENCE:

Ladies and gentlemen, it has been most inspiring to the members of the Institute to have you here today. I might illustrate this, and I am sure that most of you married men will appreciate this. Some evening when you have had a hard day at the office, you come home and find the little woman in tears. She had a row with Mrs. Murphy over the back fence, Suzie came home with her new dress torn, the cake she was baking fell, and she is just in a terrible state. You know, if you have the patience and endurance to sit down and let her tell you all the troubles she is enduring for your sake, she will feel much better. We feel very much the same way in the Institute. We work on these problems and become discouraged, then we get a group of you here together and tell you how hard we have been working. You sit here very patiently and listen to us, and it gives us a tremendous inspiration. In that way a meeting of this kind is worth a great deal to us at the Institute. It also gives us an opportunity to meet personally and hear the reports of our eminent scientists. I want to express my appreciation and the appreciation of the Quartermaster Corps for your attendance here, and bid you all good-bye and good luck.

(EVENING SESSION)

RESEARCH PROBLEMS RELATED to SURVIVAL and EMERGENCY RATIONS

DR. BERRYMAN:

I would like to raise the following question to introduce the evening's discussions: "What phases of the low-calorie, low-protein problem do you think should be investigated in the immediate future?"

DR. KING:

1. Check on the 1,800 caloric intake level to determine the net effect of a lesser degree of caloric deficiency, but with the same supposed ideal combination of carbohydrates, protein, and fat.

2. Include whole egg and such foods as oatmeal that give as broad a provision as possible of all of the nutrients.

3. Investigate the effect of variation in caloric output - widespread from the convention-

al restricted caloric output. Attempt to push it up to 4,000 calories with a definite work schedule.

(Alternate) Check the entire low-calorie, low-protein feeding program at very low environmental temperatures.

DR. POLLACK:

Would like to wait until the 40-day test is over before making recommendations.

Certainly would recommend work at low temperatures be carried out.

Also investigate compensatory mechanisms and develop a ration with the idea of protecting those compensatory mechanisms as much as possible.

DR. ALLISON:

1. Continue the studies on the relation of the physiological state of the animal to the utilization of proteins.

2. Investigate the "protein utilization factor" further.

3. Finish some of the studies on the optimum level of fat.

DR. SWANSON:

1. Define a good state of protein nutrition including evaluation of nitrogen balance. Establish quantitatively and qualitatively the amino acids needed to maintain that state in the normal animal. Investigate influence of metabolic stimulants and of work on nitrogen metabolism.

2. Investigate the relation of fat (quantity and quality) to nitrogen metabolism.

3. Investigate the "how" of the methionine phenomenon in those aspects which are not related to methylation.

DR. SCHWIMMER:

1. Determine effects obtained during a 40-day deprivation period, instead of the customary 10-day period.

2. Repeat experiments using whole egg protein.

3. Investigate the use of methionine in smaller amounts.

4. Investigate the effects of increased caloric output.

5. Investigate further the effects of periodicity of feeding, particularly on hypoglycemia.

6. Study ketosteroids routinely in all experiments.

7. Determine the effects of anti-thyroid substances.

8. Carry out detailed studies in the cold.

DR. CANNON:

I would introduce a note of pessimism. Dr. King doesn't want to restrict the word "survival" to 10 days, and I wouldn't restrict the word "survival". The problem of survival is not from ditching or airplane crashing, but the survival of whole nations is going to be the military problem for the next war. This work really constitutes what is a pioneer step toward a real survival ration. When atomic bombs start falling, cities will have to be evacuated. The problem of protein utilization in relation to vitamins, economy of processing methods - there

is just an ever-widening circle - that will end in the real survival ration as I see it. This is just the first step. I would think of this as just part of the big problem, the existence of whole populations. Almost anything that we work on may be contributing. The thing that has interested me is that within 2 or 3 years we have taken recognition of the fact that there is a continuous demand in a normal individual for a minimum amount of amino acids in order to maintain nitrogen equilibrium. I think we are going to have to consider the matter of economy. These rations are not inexpensive.

DR. DEUEL:

1. Study the effect of fat on nitrogen sparing and undernutrition.

2. Investigate adaptation to large amounts of fat.

3. Study appetizing ways of presenting fats.

DR. JOHNSON:

1. Provide enough of the survival ration to determine by field tests the physical and psycho motor effects produced as compared to those obtained when using other rations.

2. Study the possible adaptation of man to low caloric intakes.

3. Study carefully the relationship of the survival ration to the stress of environment and work, insofar as caloric requirements are concerned.

CAPT. ROTH:

1. Investigate further the effects of mixed sources of proteins on nitrogen balance. Optimum ration development at the Institute will be delayed by lack of information relative to amino acid supplementation from mixed sources of protein. More flexibility can be achieved if it is known that a number of protein sources can be used in various combinations with a minimum nitrogen load upon the kidneys. Protein metabolism should be appraised in these studies by other indices than nitrogen balance.

2. Investigate the mechanism whereby fat contributes to protein utilization and the influence of the quality of fat upon it. Continue the study of the influence of fat level upon protein metabolism when either 3.0 or 6.0 gm. nitrogen are fed. The results from Dr. Schwimmer's first series of experiments at the 900 calorie level with 30 percent fat (by weight) warrant elaboration for confirmation and to exclude the possibility of group differences which appeared to be present in the control phase.

3. Continue studies on the effect of energy expenditure (work and/or exposure to low environmental temperatures) upon the relation of protein metabolism to reduced caloric intake. The energy expenditure should impose sufficient stress to exert a measurable influence, if there is one (e.g. 3500 to 5000 calories).

DR. HENSCHEL:

Human function tests should be emphasized, since the only real test of the adequacy of any ration is the way the human stands up under stress while living on the ration.

DR. BELDING:

1. Determine the effect of frequency of feeding, especially where large caloric intakes are involved.

DR. ROBINSON:

1. Investigate the role of acclimatization to fat. Since it is possible to tolerate more and more fat in a diet, method by which the fat is prepared and by which it is used may determine this tolerance.

2. A 10-day survival period should be contemplated for the Air Forces.

3. Determine the effects of cold, different workloads, and the effect of a caloric intake as high as 6,000 calories. I think all of this work will be of more value if we do complete metabolic studies, including energy, water and nitrogen balances.

DR. LIGHTBODY:

I indorse the ideas of Dr. Cannon and Capt. Roth and think a higher priority should be given to determining the sources of protein that could be used in the ration. In the Survival Ration presented today as representing the present state of development, we are limited to one source of high quality proteins; namely, those of eggs. These make up about 50 percent of the total protein of the ration. The remaining 50 percent of the proteins in the ration are largely blank spots insofar as accurate information regarding quality is concerned. Additional sources of high quality proteins, abundantly available--and cheap, are needed.

DR. BERRYMAN:

I would like to ask for an expression of opinion concerning the relative importance of vitamins for inclusion in a survival ration.

a. For a 10-day period - 1 voted in the affirmative.

b. For a 25-day period - 14 voted in the affirmative.

c. For a 40-day period - unanimous.

There is one other question I would like to raise this evening. What suggestions have you for the direction of future research pertaining to survival and emergency rations?

DR. SCHWIMMER:

I would like to repeat the suggestions I previously offered for the low-calorie, low protein problem. (See page 27.)

DR. POLLACK:

In working with people subjected to low calorie intakes over long periods of time, one is struck with the fact that a large group develop compensatory mechanisms which allow them to survive. Some of them do not develop these mechanisms and die. Perhaps we should use longer test periods to find out what those mechanisms are.

CAPT. ROTH:

(To Dr. Schwimmer) Why have you selected the particular diet of 900 calories, with 25 percent protein, 30 percent fat, and 45 percent carbohydrates?

DR. SCHWIMMER:

The 900 calorie diet with these percentages was the lowest in calories and weight which would produce the desired objective with the greatest caloric density.

CAPT. ROTH:

Are 900 calories enough for the Arctic? Are you using an optimum diet?

DR. SCHWIMMER:

There has been a little additional work on some of that, particularly with 6 gm. of nitrogen at a 900 calorie level. The 1,800 calorie diet does better as far as decreasing kidney load is concerned. This ration that I quote at 900 calories was not primarily aimed for the Arctic at all. The minimum ration in weight, space, calories, everything else, that we could

get to fulfill the demands was the 900 calorie ration, In our re-runs at that level we have actually hit nitrogen balance. For arctic purposes you can just feed your man an additional unit for every 10 or 20 degrees the temperature drops. The weight and space requirements have made it necessary to hold the calories down.

DR. HENSCHEL:

Do you plan to do water balances?

DR. SCHWIMMER:

We haven't done any so far.

DR. POLLACK:

I wonder how much of a bugaboo dehydration is. The ones who survived in concentration camps were the ones who dehydrated. Is it desirable to dehydrate these people early in the game to help to bring into play compensatory mechanisms, or is it desirable to keep them hydrated? To attempt to maintain normal physiological status under abnormal conditions is contrary to nature. There is also the question of frequent feedings, or one large meal. With the latter there is large heat production and water loss. Frequent feedings allow for better heat dissipation.

DR. SCHWIMMER:

During a 10-day period we can't have too much dehydration. We find that during the first 3 days there is a general drop in urinary volume over what they had prior to going on water limitation. On the fourth day all start to slow down on water excretion. I would imagine that as the deprivation period is prolonged, urinary volume would go down very much.

DR, KING:

In this program you are getting data necessary for use in an intelligently planned ration which will be applicable for life raft purposes, applicable to arctic conditions where water is a critical matter, and applicable to emergency conditions in tropical areas where again maximum sparing of water is important. Secondly, there should be a provision to run a parallel group at the 1,800 calorie level in addition to the 900 calorie level as a further check on the usefulness of this ration. We ought to get such data with the least delay because the problem is of critical importance.

DR. POLLACK:

There is also the question of the injured person in a survival situation. Protein depletion following injury would amount to a great deal.

DR. KING:

A risk would be involved in deficiencies of choline in a 40-day experiment where there is approaching maximum load on kidney function. That is an additional reason for the use of whole egg and other products of high nutritive quality in a composite sense to replace purified items in major degree.

MR. GELMAN:

Dr. Elvehjem would wish to make the statement that vitamin levels might be very important on the basis of work they have been doing recently. He was referring to Vitamin B complex.

DR. SWANSON:

We have eliminated from our vitamin mixture each one of its constituent members in turn to see whether its elimination would nullify, in part at least, the depressing effect on urinary

excretion induced by supplementing the basal low nitrogen diet with approximately 400 mg. of egg proteins per day. We found that the quantity of nitrogen excreted in the urine increased when PABA, inositol, and rice bran polish factor were not included in the vitamin mixture supplementing the basal diet fortified with egg proteins. In another experiment, we secured evidence that positive nitrogen balance in the guinea pig is associated with the quantity of ascorbic acid administered.

DR. CANNON:

In testing protein-deficient rats, if we take out all the vitamins, the animals ride along 3 or 4 days making gains, then go back to the base line. If we take one vitamin at a time; i.e., riboflavin, pyridoxine, thiamine, they go right back to the base line. Other vitamins made no difference.

DR. POLLACK:

Riboflavin is unquestionably concerned in protein metabolism. When there is a negative nitrogen balance, there is an increased riboflavin excretion, and in a positive nitrogen balance, riboflavin is retained. The effects are immediate.

MR. GELMAN:

In connection with periodicity of feeding, if there is any interest in keeping appetite intensity at a minimum, it would be more desirable to feed frequently rather than only 2 or 3 times.

CAPT. ROTH:

When the subjects would eat as little as a single 1-ounce bar of the ration, they felt a sensation of warmth throughout the entire body. I wish that had been confirmed by objective measurements, but this subjective observation was volunteered by the subjects after their exit from the cold chamber. Whether or not this was purely a psychogenic phenomenon is difficult to say.

DR. ALLISON:

We find that the utilization of protein is a function of the physiological state of the dog as well as of the pattern of amino acids fed. A dog, depleted in protein stores, utilizes protein nitrogen better than a normal animal. A fat animal will utilize his protein better than a dehydrated, lean one. Our approach to the problem is to study the effect of changing the physiological state on the utilization of proteins and then to determine the job that different patterns of amino acids will do in correcting shifts from normal.

DR. BERRYMAN:

Investigation of effects over longer periods may not be important for 10-day survival, but we can conceive of an entire civilian population having to go underground, and survival rations would be required for quite some time. From that standpoint there is a basis for longer-period work.

DR. POLLACK:

Is balancing nitrogen what we are trying to do? We mustn't lose sight of the fact that nitrogen balance is not the ultimate criteria. Negative nitrogen balance may be all right if we can protect the liver and heart proteins.

DR. SWANSON:

We are trying to emphasize in our studies the value of nitrogen balance.

DR. CANNON:

What we are interested in is <u>degrees</u> of nitrogen retention rather than just balance.

DR. DEUEL:

We reported experiments in which we showed that methionine could not cause any sparing action on the human either in cases where the individual was on a very low protein diet or practically on a protein-free, high carbohydrate diet. Apparently the individuals have a lower amount of sulphur breakdown than the rats or dogs. The rat and dog have a considerable portion of metabolism concerned with hair, and since hair has such a high sulphur content, possibly the higher sulphur turnover in these animals might be related to this.

DR. ALLISON:

I believe that there is a difference in the quantitative requirements for methionine by the rat, dog, and man but that there is no fundamental difference in the metabolism of methionine in these species.

DR. JOHNSON:

One kidney disease, nephrosis, is characteristic among certain groups of Eskimos and I wonder if this is a reflection of the relationship between choline and kidney disease? In the 40-day experiments you certainly have to worry about all the vitamins because there have been reported cases of scurvy in 40-day missions. One should think about defects arising from an abrupt change in vitamin intake. Assume you have a caloric deficit of 1,000 per day in varying degrees of expenditure. Is there any great difference in the symptoms arising from those different levels? A man may need 4,000 calories for survival in the Arctic. The general question of fat is interesting. The evidence on American soldiers is against an increase in fat appetite in the cold. They always go for 30 percent to 40 percent of fat and object strenuously when they go below that. I am in favor of the experiments Dr. Schwimmer is proposing to do.

DR. BERRYMAN:

Regarding the quality of fat - if you try to provide fat with a high melting point, you get into the sort of fat which is indigestible to the human. We may be computing calories which may not be actually assimilated at all.

DR. SCHWIMMER:

Through error we succeeded in feeding a 42 percent fat ration for 10 days without causing any digestive disturbances at all. Twelve percent of the fat was from whole egg, and the other 30 percent from hydrogenated fat, just as we had used before.

MR. GELMAN:

How about the quantitative composition of the 5-in-1 ration with respect to the physiological state it might put the animal or man in? Is there any point in being concerned about the differences that might be involved in that standardization period from time to time. Is it the proper thing to give these people when you consider the physiological state it puts them in; i. e., the ham and egg components make it difficult to deplete them.

DR. SCHWIMMER:

I think the degree of error in interpretation was at a minimum. If we had to do away with the 5-in-1 ration, it would cost us $4.00 per man per day more.

DR. ROBINSON:

I think there hasn't been enough consideration given to energy balance studies. How much environmental protection can we afford to give these people? From that standpoint we might consider the desirability of using the sleeping bag. Men in a temperature of -20°F. were happy to stay in the bag about 10 hours per day. We calculated that the bag protected them 1,200 calories per day. It weighs 16 1/2 pounds, and if we took the 16 1/2 pounds and put rations in instead, it would give us 27,000 calories. Subtracting from that 1,200 calories per day for 7 days, we found we had lost 19,000 calories over a 7-day period. That turns out to be 2,700

calories per day, and if we had added that to what they got, they could have had 4,700 calories per day in the form of food.

DR. BELDING:

We have also made a few calculations which demonstrate how essential a sleeping bag is for the survival of men under arctic conditions. Without a bag and with the best present arctic clothing, a man must expend 7000 to 8000 calories/day at -20° F. just to keep warm. To provide that much heat, the man must do work equivalent to walking at 3 1/2 miles per hour for well over the time, day and night. If the same man has an adequate sleeping bag awaiting rescue and stays in it 15 hours a day, he can be comfortable with expenditure of only half as much energy, 3500 to 4000 calories/day.

This calculation as well as Dr. Robinson's not only points to the necessity for providing a sleeping bag, but also indicates the desirability of setting up studies to determine the relationship between work capacity and reduced caloric intake.

DR. MELNICK:

In nutrition studies with animals the usual practice is to mix the protein, fat, and carbohydrate components and feed the simple admixture. In human nutritional studies this is seldom done since palatability is an important factor. This has required modifying the form of the mixture to yield a product which can be consumed in the required quantities over the specified period of test. Thus, water may be added and the mixture baked or some other change introduced. In heat processing, however, availability of nutrients may be modified. We know that lysine availability is impaired in heating protein materials. The lysine may be demonstrated to be present in the protein but to be not biologically effective, with the result that a response is obtained characteristic of that yielded by a deficient protein. The sugar-amino acid reaction may also take place during heat processing, with a resulting impairment in the value of the product due to the production of toxic materials and-or destruction of essential nutrients. Therefore, investigators in the fields of human nutrition interested in applying the results of animal nutrition studies should take cognizance of the fact that in a processed ration the nutrient composition may not be the same as that employed in the animal feeding studies, despite the fact that the same ingredients, even from the same batches, may have been employed in the formulation of the 2 types of rations. This may explain in part discrepancies obtained in studies with animals and man which too frequently have been attributed solely to species differences.

DR. DEUEL:

The problem now is whether one can demonstrate any alteration in the nutritive efficiency of food when you develop the browning reaction to any extent. Can you get food so completely browned it may be nauseating, which will still produce nitrogen equilibrium, provided they can get it down?

DR. HUNTER:

In laying your plans for evaluating the inter-relating effects of clothing, exposure conditions, and emergency rations, do not overlook the fact that the facilities of the Climatic Laboratory will be available where indicated. As soon as the Institute of Man is in operation the Arctic and the Tropic-Desert chambers will be exceedingly valuable in carrying out coordinating experiments of this type which will be of interest to all the Services.

DR. BERRYMAN:

Mr. Gelman, do you have anything you wish to add before the meeting is closed?

MR. GELMAN:

We should make certain that people responsible for menu planning take cognizance of this plan as it unfolds. At the Institute we might put our Food Composition Section to work with more objectives in mind than has been the case with respect to the physiological state.

DR. BERRYMAN:

We appreciate the time and effort you have all given in attending this meeting, and we hope you have benefited as much as we have.

APPENDIX A

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APPENDIX B

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